
IN HOC SIGNO VINCES
Berry of Tayfield

SUPPLEMENT

TO THE

ENCYCLOPÆDIA BRITANNICA.

SUPPLEMENT

TO THE

FOURTH, FIFTH, AND SIXTH EDITIONS

OF THE

ENCYCLOPÆDIA BRITANNICA.

WITH PRELIMINARY DISSERTATIONS

ON THE

HISTORY OF THE SCIENCES.

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VOLUME SIXTH.

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Supplement

TO THE

ENCYCLOPÆDIA BRITANNICA.

NAI

Nairnshire.

Situation and Extent.

NAIRNSHIRE, a small county in Scotland. It is situated between 57° 22′, and 57° 40′ north latitude, and 3° 35′, and 4° 7′ west longitude, having the Moray Frith on the north, Morayshire on the east and south, and the county of Inverness on the west. Its extent, from north to south, is from 12 to 20 miles, and from east to west from 10 to 13; and its contents are 198 square miles, or 126,720 English acres, of which only about a fourth part is in cultivation; the rest consisting chiefly of wastes, with about 10,000 acres of wood, natural and planted, about three square miles of lakes, and a small proportion of moss. It has only four entire parishes, Ardclauch, Aultdearn, Calder, and Nairn, and portions of other five, which belong to the counties of Moray, Ross, and Inverness. Two detached districts, Ferintosh and Dunmaglass, belong to Nairnshire, the former lying near Dingwall, in Ross-shire, and the latter at the head of Strathnairn, in Inverness-shire.

Surface, &c.

Along the Moray Frith, and for a few miles inward, the surface is generally low, and much of the soil productive, being partly loam, and partly clay, both of them fertile. Farther south the country rises into hills, containing but a small proportion of arable land, and this chiefly a sandy loam or gravel. The only streams of any note are the Nairn and the Findhorn, both of which it receives from Inverness-shire. They have a nearly parallel course from south-west to north-east. The former flows into the Moray Frith, at the town of the same name, but the latter, before entering the Frith, passes into the county of Moray. The Nairn is, therefore, the only river which can be said to belong to this county, and it is inconsiderable; but its banks are in many places well wooded, and it has a small salmon-fishery. Marl is found in several places, particularly on the estate of Lord Cawdor, in the vale of Litie, where it is of an excellent quality; and in the same quarter, and at Kilravock, there are some quarries of sandstone.

Estates.

The territory of Nairnshire, exclusive of the lands belonging to the burgh of Nairn, is divided into fifteen estates, of which nine are under the valuation of L.500 Scots, other three under L.2000, and the remaining three above L.2000; and a few years ago the number of freeholders entitled to vote in the election of a member for the county was 22. The valued rent is L.15,162, 10s. 11d. Scots, of which about one-sixth is entailed; and the real rent, in 1811, was, for the lands, L.11,725, 14s. Sterling, and for the houses L.216. The principal seats are Cawdor Castle,—Lord Cawdor; Kilravock Castle,—Rose; Boath,—Dunbar; and Kinsterie,—Gordon.

Farms.

This county is further subdivided into farms, for the most part small, and, with few exceptions, open, and ill cultivated, producing oats, bear or bigg, and potatoes, but very little wheat. Turnips and clovers do not yet enter into the usual course of crops. Its live stock presents nothing worthy of particular notice. Though the natural circumstances of the dis-

Nairnshire ‖ Naples.

trict do not seem to be very different from those of the contiguous county of Moray, except that it has no harbours, yet its rural economy is greatly behind that of the latter county.

Towns.

Nairn, the county town, and a royal burgh, is a place of considerable antiquity, and pleasantly situated; but having no harbour, it is without trade or manufactures, and contains only about 2000 inhabitants. According to a survey made by Mr Telford, a commodious harbour may be formed for about L. 3000. The villages are Auldearn and Calder.

Representation, &c.

This county sends a member to Parliament alternately with the shire of Cromarty; and the town of Nairn joins with Inverness, Forres, and Fortrose, in the election of a member for the burghs. The counties of Moray and Nairn are under the jurisdiction of the same sheriff, who has a substitute for the latter county in the town of Nairn.

Antiquities.

Nairnshire formed a part of the ancient province of Moray. On the estate of Lord Cawdor, at a place called the *Hoar Moor*, Macbeth, according to Shakespeare, met the witches when upon his way from the Western Isles to Forres; and a bedstead, said to be that on which Duncan was assassinated by the usurper, is still preserved in the Castle of Cawdor. Near the village of Auldearn, Montrose obtained a great victory over the Covenanters in 1645. The county contains the ruins of several castles, and other remains of an early age. The Castles of Calder or Cawdor, and Kilravock, both of great antiquity, are still the seats of their proprietors.

The population of this small county is shown in the following abstract.—See *The Beauties of Scotland*, Vol. IV.; Leslie's *General View of the Agriculture of Nairn and Moray; The General Report of Scotland;* and Playfair's *Description of Scotland*, Vol. II. (A.)

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
1,940	1,945	32	3,639	4,618	2,901	898	4,456	8,257

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
1,946	2,021	68	3,530	4,721	870	341	810	8,251

NAPLES.—The history of Naples, down to the period when Bonaparte bestowed its sceptre on Murat, is given in the *Encyclopædia;* where also will be found a general description of the country. The succeeding historical events of any importance will be found under the articles AUSTRIA and FRANCE, in this *Supplement;* and there is some notice of its statistics, under the general article on ITALY. The present article is limited to the late Revolution; of which, and of its issue, the Editor has received the following account from the pen of an intelligent Neapolitan.

The last revolution of Naples, although it ended unexpectedly, without advantage or honour to the nation, is very remarkable, if we consider the political death (if we may so speak) to which Italy had been doomed during three centuries, not only as a power, but as a people; and when we recollect that this was the first political movement which, for seventy years, merited the name of a national one in Italy. It was attempted and brought about, not foolishly to benefit foreigners, and with foreign troops, according to the old custom of the Italians, but for Italian interests, and with Italian forces.

Causes and Progress of the Revolution.

On the fall of the French empire, Murat was expelled by the Austrian arms from the throne of Naples, and Ferdinand restored (May 1815). The condition of the new government, though at first sight promising, was beset with great difficulties. The Bourbon ministers found, on their return from Sicily, that an immense power had been usurped by the Crown, during the French government, the period of which was now called the *Decenio*. All aristocratical hierarchy, all municipal franchises,

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were destroyed. From the highest affairs of state, down to the meanest municipal concern, the prince ruled every thing by a host of public functionaries. But all this authority was supported solely by a standing army organized by the French, which the king did not trust; and by a revenue of 16,000,000 of ducats, which, having been only derived from the rapacity of the French financier, had, at the end of ten years, become intolerable. They found, besides, the dispositions of the people very much changed. The Neapolitans, who seldom liked their governments, had grown more than ever indifferent to the person of their prince, reluctant to submit to absolute power, and well aware of the only effectual remedy to restrain its abuse. But a cause, more powerful than all these, assisted in imbuing their minds with the principles of liberty. A political association, known by the name of *Carbonarism*, had sprung up, and experienced various fortunes under the French. At first it was despised, because its real object was yet misunderstood; it was afterwards fiercely persecuted by Murat, and finally caressed in vain by his ministers, who sought in it a support to his tottering throne. But such a forced retractation of his former steps availed Murat nothing in adversity. The nation was alienated from him, and hoped to gain by a change of princes. King Ferdinand had, in a proclamation from Palermo, promised a constitution, by which the people should be *the sovereign*, and the prince a mere *depository of the laws.* Murat, vanquished and despairing, attempted to throw out a lure to the Neapolitans, by causing a constitution to be proclaimed a few days before the Austrians occupied that capital. Chevalier Medici had now succeeded to Count Zurlo, and alone governed the state. This minister felt no blind party prejudices against reforms that had arisen out of the revolution. His objection was solely that of ministerial interest. Esteeming the Neapolitans to be unsteady in their wishes, he would not shock their political opinions, but rather strove to delude and rule, without satisfying them. Every thought of the new minister was bent upon finance; for the new government had assumed the discharge of enormous responsibilities. The negotiators for King Ferdinand, at the Congress of Vienna, were forced almost to redeem his crown from Austria, at a time when so much noise was made by the allies about the doctrine of legitimacy and restoration. They bargained to pay 6,000,000 of ducats to the imperial treasury; 1,150,000 ducats a year for the support of the Austrian troops in the kingdom; and 1,200,000 ducats to Beauharnois, ex-viceroy of Italy, for indemnities due to him by Austria. The disgraces and burdens imposed upon the nation did not stop here. Naples became tributary even to Rome and to the piratical states of Africa. Rome would not consent to satisfy the conscience of the king without a Concordat, by which an annual revenue of 12,000 ducats in land was assigned to the Roman treasury: thirty-six convents were re-established and richly provided for by the state. The ordinary administration was no less tainted with prodigality. Medici, following the example of France, endeavoured to prop the immense authority of the crown with the order of public functionaries left by the French, who were so numerous, and so closely bound together, by their opinions and interests, that they resembled a new aristocracy. Hence the public offices, which already pressed so heavily upon the nation, far from being reduced, were daily augmented. From all such causes resulted a government that was passive, but rapacious. The prime minister seemed to govern only to raise taxes. The French imposts, chiefly the land-tax, which had been always burdensome to the nation, now caused general complaints, on account of the extreme depreciation of corn and oil, attendant upon the peace of Europe. These chief products of a country entirely agricultural, now scarcely brought a third of the price which they had held a few years before. Yet for a small profit of the treasury, foreign merchants were allowed to import their corn into the kingdom, where it sold at a very low price, and almost entirely interrupted the sale of home wheat. The distress augmented in a short time to such a pitch, that in Apulia, the old harvest was often thrown into the sea to make room for the new one in the granaries. The land proprietors, rich and poor, remonstrated with the government, and offered to discharge the imposts with the very products of the soil; and these soon becoming unequal to taxes and culture, the lands began to be abandoned—a lamentable, but certain mark of the rapacity of the government and of an approaching revolution. The country was overspread with internal custom-houses from one borough to another, for external trade yielded little; contraband commerce increased, and the amount of the loss was surreptitiously overcharged upon the lands. The most trifling transactions were committed to stamped paper, and registered. In short, every expedient, however ruinous, was esteemed good, provided it could afford immediate money. By such means the public revenues were in three years stretched to more than 20,000,000 of ducats; but, for this augmentation, the subject was wrung, moderately speaking, of half his real income, at a time when the national industry was sinking into a state of unprecedented wretchedness. This fiscal delirium could not have lasted long. The farmers were impoverished, the middle classes were reduced to despair; discontent rapidly spread into the provinces, and the general wish for a reform was little dissembled. Carbonarism, checked only for a time by the denunciations against all secret societies, which followed the restoration, now rose in double strength. But an event, which had once threatened its extermination, contributed even more to its revival. The minister of police, the Prince of Canosa, detesting the very name of French innovation, designed to force back the nation to the state in which it had been ten years before. He considered the Carbonari as *Murattites,* or partisans of the French, whilst they are only votaries of liberty and enemies to despotism, by whomsoever exercised. The seeds of another sect adverse to Carbonarism had been sown since the time of the French by a bishop, who was an enemy to their government. This was composed of a

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species of loyalists, the dregs of the people, chiefly rioters, who had participated in the counter-revolutionary massacres of 1799. They assumed the name of *Calderaj*. The minister of police exerted all his influence to rally them with mysterious rites and signs, and to arm as many of them as he could. In a little time their numbers exceeded 60,000, and they were generally believed to be ready to fall upon the Carbonari or Murattites on the night of Holy Thursday 1816, and, renewing the example of the Sicilian vespers, to massacre them all over the country. The minister, thus become master of the state, could have reformed it according to his own will. But the horrible plot was soon discovered; and Medici, who professed quite different politics, and was then all powerful, caused the minister of police to be banished to Lucca. Thus Medici saved his country from a dreadful civil war; the new sectaries were easily disarmed, and soon sunk into oblivion. But the Carbonari, who were aware of their danger, and had united more closely than ever, would no more separate, after having once rallied for their common defence. Nay, three years were sufficient to draw into their association all the active part of the people, and to convert the rest to their political religion. Whether by the lapse of time, or by the recent example of the free constitution of Sicily having been overturned at one blow, it had become evident that the promise from Palermo was mere state-craft to hasten the fall of Murat. The patriots, judging themselves strong enough in the provinces of Lecce and Bari, reminded the king of his pledge, with bold and reiterated remonstrances; and demanded a constitution, together with the repeal of the land-tax, within a certain term. These petitions being disdained, the town of Lecce rose in a commotion (1817), and nothing was wanting to a revolution but support from the other provinces. But the cause of Carbonarism was yet neither so strong nor so unanimous as it became soon afterwards. A new sect had sprung from it, which seemed to incline more to democracy, and was much spread among the lower classes of people in the provinces of Lecce and Bari. This sect, by introducing licentiousness and violence in popular opinions, divided and enfeebled the party, and soon became odious to the best intentioned of the patriots. On the first news of General Church having marched with some troops against Lecce, a few hundreds of the new sectaries took to arms, and overran the country in bands. The Government commander easily diverted or quelled this insurrection. By dexterously availing himself of the discord of the patriots, and showing the moderate they had nothing to fear from him, he succeeded in amusing a great many, and subduing the rest. All the armed were proscribed, many fell in the field, and several were put to death, or confined in the Sicilian islands. But discontent had crept even into the army. Most of the military having been trained by the French, when there were no bounds to fortune and honour in their profession, were impatient of the restored government, which used soldiers only to keep down the people. Besides, the mal-administration of the war minister (a German officer), the penury of the finances, the jealousy of the Austrians, and the partiality of the king towards the military who returned with him from Sicily, had greatly injured the army, and divided it into two adverse parties. This hostile disposition was soon turned to the national advantage by some patriotic chiefs, the principal among whom was William Pépé. This general had been disposing affairs for a revolution, during two years that he held the military command in the provinces of Foggia and Avellino. He had formed there no less than 10,000 militia, chiefly composed of small land-proprietors, armed and clothed at their own expence, and commanded by the country gentlemen, who were exasperated against the rapacity of the administration. Such a militia was well qualified for accomplishing a revolution; yet they were tolerated by the prime minister, on account of the great services, without any expence, he drew from them; for they had, in a short time, scoured the country of the banditti, who are ever swarming in that kingdom. Thus to save money, arms were entrusted to that very class which was most interested in national reform. So capital an error of despotic policy may well characterize the administration of Medici as entirely financial. Every thing, therefore, hastened to a revolution, when the news arrived of the movement at Cadiz. This example banished from the multitude all remaining doubts as to success. It taught the chiefs how to act; and in a natural spirit of imitation, they chose the constitution of the Cortes for their model. This constitution, moreover, seemed to be the only monarchical one fixed at one effort by the representatives of a great nation, and still unimpaired by the abuses of power and time. The patriots now began earnestly to think upon a general movement. William Pépé, considered as the chief of the enterprise, communicated his plan to some superior officers of his division, and a few citizens. They agreed that the general should, under pretence of a muster, assemble, on the 25th of June (1820), his 10,000 militia at Avellino, where he was to be immediately reinforced by five regiments of horse quartered at Foggia, Nola, Nocera, Aversa, and Naples, and by all the armed patriots of the two Principati and Capitanata: a camp was then to be formed, and a petition sent to the king, demanding the constitution. The signal being thus given, no doubts were entertained of a general and ready support from all the provinces. But owing to the want of resolution of one colonel, this plan failed. The general, judging it convenient to delay his design for a short time, went to Naples, where he had been repeatedly called by the government. But, in these perplexities, Morelli, a young lieutenant, unexpectedly departed from Nola, on the night of the 1st of July, with 130 horse, and, marching to Avellino, threw down the gauntlet. The revolution had been long since ripe in the minds of the Neapolitans, and the departure of Morelli was only the signal for its accomplishment. At the first intelligence of his march, Foggia, Avellino, and Salerno, took up arms, and proclaimed the Spanish constitution. An intrenched camp was formed by the constitutionalists in the strong passes of Monteforte, and thither the militia, the patriots, and most of the

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standing army, flocked from all directions. General Pépé having defeated the precautions of the cabinet, by which he was still obstructed in the capital, led some more troops to the camp, and took the command of the whole. The government, awakened from its slumber, had already attempted force. Generals Carrascosa and Ambrosio were sent with some troops against the constitutional camp, whilst Generals Campano and Nunziante were to attack it rearwards from Solofra. But all proved vain. Campano was bravely repelled by the constitutionalists, led by Colonel Deconcilj. Carrascosa, perceiving the majority of his troops more inclined to join their comrades than to fight against them, would not hazard a battle. The government, now despairing of succeeding by force, recalled him, and prepared itself to satisfy the nation. The court, indeed, made a last effort to divert the storm by a royal promise of a constitution to be settled *in eight days*. But this state-expedient could not deceive men to whom no choice was left but between the scaffold and success:—The proposal was refused. The capital was in commotion. The King, yielding to the entreaties of his oldest friends, consented at last to the constitution of the Cortes. Secret protestations, however, are said to have been addressed from that very moment to the five great powers of Europe, ascribing that concession to mere force, and invalidating it in all its consequences.

Occurrences between the Establishment of the New Constitution and the Austrian Invasion.

The whole of this revolution was brought about in six days, with a facility and mildness that proved the public mind to be ripe for free institutions. But the royal personages were not so easily consoled for their loss of power. The king showed this, by resigning the government to his son Prince Francis, who assumed the title of Vicar of the Kingdom. The constitutional camp, 15,000 strong, was raised at Monteforte, and marched to the capital. Many errors were committed in that camp. An egregious one had been to intrust power to persons whose lives and fortunes were not staked on the revolution. Fortune no sooner seemed leaning to the side of the constitutionalists, than the disappointed ambitious spirits of *the decennio* awoke, and laid hold of the first places of the state. Count Zurlo, who had persecuted the patriots, and who had seconded various changes of power and principles, reappeared at the helm of the state. His colleagues had been, like him, the courtiers of Murat, and little cared for the new liberty of their country, if it was to be preserved at the cost of their personal danger and sacrifices. Almost all the offices, civil and military, were left in the possession of a set of men accustomed to change sides from the vanquished to the vanquisher. A revolution which had been thus defective in decision at home, was farther menaced from abroad. Austria soon evinced a profound resentment at the revolution of Naples, both by diplomatic protestations, and by rejecting the new Neapolitan envoys as the representatives of rebels. From the beginning these true patriots had no other chance of success than to have invited all Italians to arms, while the Austrians were still weak in Lombardy. But the new government had not courage for this, and the opportunity for raising Upper Italy by surprise had nearly vanished, when the unfortunate revolution of Sicily broke out.

Sicily is the only country in Italy where the feudal aristocracy is still strong. This island had escaped French subjection to fall under that of the English, who here combated Bonaparte with the principles of liberty. Nevertheless the Sicilian constitution, given in 1812, left the power of the House of Commons in the hands of the nobility. But even the few benefits which could have accrued from English ascendancy were lost by the constitution being abolished as soon as it could be dispensed with. Medici attempted, in 1819, to introduce the French administration into Sicily, but the nobles generally resisted such innovations, and the people, through inveteracy against the rule of the Neapolitans, supported their resistance. After the revolution on this side the Pharum, the Spanish constitution had scarcely been proclaimed at Palermo, when the chief Sicilian nobility instigated the people to proclaim Sicily independent of Naples. The Neapolitan garrison of Palermo being furiously attacked by the mob, and overwhelmed with stones, boiling oil, and other missiles thrown from the houses, surrendered at discretion after a dreadful contest. But the Sicilian nobility, after they had allured the people by the promise of independence from Naples, wherewith they covered their design of re-establishing the aristocratic constitution, found that it was easier to raise than to guide a sedition. For the people proclaimed independence, and the constitution of the Cortes cut off the heads of Princes Aci and Catolica; and even whilst following their aristocratic leaders, menaced them with the axe. At last General Florestan Pépé was sent into Sicily with a squadron and 6000 troops. He landed at Messina, defeated the revolted Palermitans at Termini, and obliged Palermo to capitulate, delivering the city from a state of the most frightful anarchy. But that capitulation, which yielded to the independents the separation from Naples, which they had been unable to get by force, was soon annulled by the Neapolitan Parliament. The general was recalled, new troops were sent out, and Palermo was held neither in friendship nor enmity. The majority of the Sicilians, however, seemed to decide the question against independence by sending deputies to represent them at Naples.

The Parliament had now assembled at Naples, and received, on the 1st of October, the constitutional oath of the king. The liberty of Naples was to depend upon this assembly. The Spanish constitution had been granted, excepting the necessary alterations to be settled by the representatives in its adaptation to the Two Sicilies. Yet, at the bottom of this proviso from the court lay a design to increase, as much as possible, the constitutional power of the Crown by a servile Parliament. The ministry had endeavoured to influence the elections; but the name of Zurlo was so unpopular, that the slightest suspicion of interference had been sufficient to exclude a candidate, whatever might be his experience in public affairs. The people, suspecting the nobility of a wish to introduce an hereditary chamber in

the constitution, had hooted them off the hustings. Owing to this national disposition, the Parliament had been mostly composed of men who had never exercised any public office. The majority of them were of an upright rather than firm mind; some were versed in literature, none in state-craft; many ignorant of every thing, trusting more to the justice of the public cause, and to the effects of mildness towards the Crown, than to their own intrepidity and credit with the people. The Parliament applied itself to the diminution of the public burdens, though the military expences had nearly exhausted the treasury; chose a new council of state; made good municipal laws; and reorganized the army. At first it was well seconded by the nation. The dismissed veterans flocked spontaneously back to their banners on the first call of the government, and soon exceeded the number demanded. The Calabrese militia gallantly supported the army in Sicily. Several provinces paid in advance the very land-tax which they felt so heavy. But the ministry made all this useless to the state. Every step of the executive power betrayed slackness, reluctance, and perfidy; in a word, it destroyed the liberty and independence of Naples. The court looked for support to that mysterious alliance which styles itself *Holy*. A congress had met at Troppau, where an independent people were to be sentenced for having offended against despotism. The Parliament, guessing the design of the court, applied itself to a speedy reform of the constitution, that it might be finally sanctioned by the king. The prospect of eluding the effects of the revolution in a pacific way being over, a *coup-d'état* was resorted to; and some members of the diplomatic body then at Naples agreed with Zurlo upon the manner and time of the new experiment. It was known by the public that the congress at Troppau had ended, and much uneasiness prevailed for some days in the capital. On the 7th of December, a royal message was brought into the Parliament by the ministry, in which a vague and conditional promise of a new constitution was substituted for the existing one. It was announced that the king was going to a new congress, and all farther deliberation was forbidden to the representatives. The message was at the same time placarded in the capital, and forwarded into the provinces, and every practice was employed to carry the point by surprise. But all this only tended, for the present, to the triumph of the nation. About 15,000 patriots assembled in arms, and remained together for three days, ready to repel force by force, if necessary. Speedy intelligence was dispatched into the country, and many places rose in arms at the same time. The Parliament, being thus supported, rejected the message, but permitted the king to go to Laybach, provided he should do so to plead the national cause. Then an impeachment was moved against the ministry, and two were called to the bar (Count Zurlo and the Duke of Campochiaro); but the cabal of the courtiers prevailing, it was adjourned *sine die*. The king, after declaring he never meant to injure the existing constitution, asked again for the opinion of the Parliament as to his departure. A new consent was given, and the king embarked aboard an English man-of-war, landed at Leghorn, and proceeded to Laybach.

The departure of the king, to join the enemies of the nation, proved, no doubt, the immediate cause of the fall of Naples, and all Europe has reproached the Neapolitan Parliament for permitting it, as a signal act of blindness. But an English and a French squadron were anchored in the bay; 6000 royal guards were ready to fall upon the people; and the facility of embarking from the palace, and, above all, the firm resolution of the king himself, leave it even now doubtful whether that fatal departure could have been prevented. Certainly a new revolution would have been necessary for this attempt, and the Parliament decided according to what it conceived to be an unavoidable necessity. Yet the virtual failure to the enemies of freedom of their last *coup-d'état* was worth a victory to the patriots, had they fully known the value of it. The court was humbled, the credit of the Parliament re-established; and the representatives could have still saved the state, had they, during the flow of popular feeling, created a regency of a few tried and bold patriots. By transferring the seat of government to Calabria or to Messina, they ought to have prepared themselves, from that very moment, to have sustained a national war. But the Parliament was incapable of such counsels, which appeared to them rash and unconstitutional. *Moderation* was their motto. This assembly continued the regency to the Prince-Royal; suffered a weak ministry to succeed to a perfidious one; and slumbered in the capital, attending only to the reform of secondary abuses, while they trusted the cause of the country to the mediation of the king with the allies. Not having availed itself of the favourable moment, its credit and power decayed daily, and the national zeal abated simultaneously. These public perplexities lasted but a short time. The Parliament had already presented, and the Regent had finally sanctioned, the reformed code, when intelligence arrived that the Congress of Laybach had declared, that whatever had been done by the revolution was to be instantly undone at Naples, and that 50,000 Austrian troops were marching to occupy the country, and re-establish its despotic government. These *orders* were enforced by a letter from the king, in which his majesty, alleging the utter impossibility of obtaining any thing from the allies, eagerly advised a ready obedience to them. The Parliament declared that it had no power to consent to the public ruin, and that the king was to be considered as a prisoner in the hands of the enemy. This was its last effort. Laws, indeed, were heaped upon laws for the safety of the state; but the circumstances requiring practical courage far more than debates and statutes, all that was done proved useless. Even whilst the danger grew imminent, the representatives did not dare to assume the whole public power. They were still frightened by the shadow of a compact, which had been already broken by the most responsible of the parties.

The effect of the news from Laybach was, to pro-

duce mixed feelings of apprehension and indignation. The inhabitants of the provinces seemed disposed to defend themselves to the last; but they wanted experience and guides. A numerous militia had but just been formed in all the provinces, and 12,000 young men composed a national guard of an imposing appearance in the capital. But these militia, yet destitute of all military skill and habits, could only serve in a desultory warfare. Of the standing army 12,000 men remained in Sicily, in order to keep it in subjection; the rest were already cooled in the public cause, discordant in their opinions, rather relaxed in discipline, through the introduction of Carbonarism, and certainly not commanded by patriots. The Carbonari, too, fancying they had secured the revolution by the meeting of the Parliament, began to divide among themselves. Carbonarism never could settle itself into a federation before the revolution, and much less after it. Hence the upper council of Naples, which ought to have represented the whole order, and directed it to the same object, was not acknowledged in several provinces, and openly opposed in Salerno, where the opinions rather inclined to democracy. The consent of this council, which at first was required to establish inferior assemblies, was soon neglected. New societies sprang up everywhere. Indeed, all these dissentions were diligently promoted by money, promises, and every wicked practice of the agents of despotism at home and abroad. Confusion and anarchy were made pretexts both to colour and facilitate foreign invasion. After the revolution, Carbonarism ought no doubt to have been abolished by law, as dangerous to liberty itself, had the free government had nothing to fear. But this government, being undermined on one side, and attacked on the other, could not have found, in its early period, a better support than that association. The patriots of the frontier provinces attempted to rally themselves into a federation, which they called the *Samnitic League*, from the classic name of that country. But the society of the Carbonari was no longer susceptible of being recombined; and it must be confessed, that its untimely dispersion was another cause of the shameful fall of Naples.

Invasion of the Austrians, and Overthrow of the New Government.

Meanwhile an Austrian army, 50,000 strong, advanced by forced marches towards the country. The government, compelled at last by the public clamour, hastily called, by telegraph, the militia from the most distant points, when the enemy was already reaching the frontiers. The militia hastened from every quarter, but only 15,000 had arrived on the borders of Abbruzzo, when it was found necessary to fight. General Pépé was appointed to command that frontier. Near San Germano, on the left, was an entrenched camp of 30,000 men, most of them veterans who had served in the French wars. The plan of defence was, that, if the enemy attacked the right, the commandant of the left was to relieve it with troops and evolutions; if the left, Pépé should do the same. But the distance between the two camps was immense. General Pépé, with some militia and a few troops, which together did not amount to a third part of the enemy's forces, was obliged to guard a line of 150 miles in length, and accessible at five points. And the Austrian general, as it appeared afterwards, had directed the main body of his army upon him, well aware that that corps once routed, no more resistance would be offered on the left. Pépé posted himself at Civita-Ducale, a frontier town in Abbruzzo, three miles from Rieti, where the enemy established his van-guard. The Neapolitan militia, then on the frontier, was composed chiefly of substitutes, badly armed and worse trained, and incessantly harassed by traitorous agents, who represented to them that they should be treated as rebels, if they vainly persisted in opposing the great powers of Europe allied against Naples. The king himself followed the Austrians close, declaring he was at full liberty, and ordering the national forces to welcome the invaders as friends. On a sudden, some battalions of militia, posted at Arguata and Tagliacozzo, disbanded. General Pépé, dreading the example, resolved to fight instantly. Having distributed his 10,000 men in three columns, he advanced towards Rieti on the 7th of March 1821. His left, led by Marshal Montemajor, was to begin the attack at day-break; but it was ten in the morning before the order was executed, and the Austrians had already concentrated most of their forces near the Cappuccini in the plain, when they were attacked. Pépé ordered Marshal Russo to advance at the same time on the right with 200 horse and some infantry, to sustain the charges of the Hungarian cavalry, 4000 strong. The fight continued for six hours with musketry, and the Neapolitans had made several unsuccessful attempts to carry the Cappuccini, when Montemajor suddenly began to withdraw with his division, an hour before sun-set. The enemy, who till then had been perplexed by the unexpected boldness of the militia, having now his right disengaged by the retreat of Montemajor, pushed forward great masses of infantry on his left, which being extended farther than the right of the Neapolitans, threatened to surround them. Pépé was then obliged to order a general retreat, which began in good order along his whole line, under the fire of the enemy. But the militia not being trained to retreat while fighting, began to get into disorder; and, breaking their ranks, they hurried to the hills, without any longer obeying their officers. Some companies of the line, which were intermixed with them, imitated the example, and all the troops speedily disbanded. But a few hundred soldiers, headed by a body of gallant officers, covered the retreat in such a way that the enemy was scarcely aware of the disbanding, and did not advance for that night.

This engagement was sufficient to decide the fate of Naples. The Parliament, astonished and discouraged at this first blow of adversity, laid aside all thoughts of farther defence, and secretly sued for pardon from the king, whom they had but just declared to be a prisoner of the enemy. The executive power, which only waited for a single disaster to throw off every constitutional disguise, immediately strained all its nerves to accomplish, in a few days, the subjugation of the country. More shame than loss,

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however, had been incurred; and had a patriotic ministry guided the helm, the nation might have been saved, or would have sunk with honour. To transfer the seat of government into Calabria without delay; to remove the yet unbroken first corps from San Germano into the middle provinces, and to collect behind them all the remnants of the corps of Pépé, there to be rallied into a second line,—were measures that seemed as practicable as they were advisable. Under such arrangements, the arrival of the enemy in the capital might have proved the commencement of his ruin. An immense town, and four citadels held by national forces; the almost impregnable fortress of Gaeta behind; an army 30,000 strong on the front; with Calabria in insurrection, and the Parliament calling to arms a people generally sanguinary and revengeful;—these were obstacles almost insuperable against the success of the invaders. Moreover, the Piedmontese revolution breaking out soon after, would have placed the Austrians between two fires, and spread the national war from one extremity of Italy to the other. Thus the Italians would have been perhaps at this hour an independent and free nation, or at least fighting to become so. But scarcely six days had elapsed from the action at Rieti, when the commandants of the divisions and regiments in the camp at San Germano were required, by an order of the day, to frame addresses in the name of the army, to the general-in-chief, requesting him to support we know not what authority of the regent, different from the constitutional one. The army was given to understand, that the capital and several provinces had fallen a prey to anarchy, while they remained as if plunged in stupor and consternation. The first plan of the court seems to have been to march the first corps to Naples, and to put down the constitution with the same national forces which had sworn to defend it. But as a strong feeling of reluctance was evinced by some regiments, the royal guards were directed to protest openly against all resistance *to the king*, and this had the effect of dispersing the rest of the troops. The first corps had scarcely decamped from Mignano, and begun to retreat towards the Volturno, when suddenly it disbanded. The royal guards only, 6000 strong, were kept to their banners. Marching speedily to Naples, they shut themselves up in the fortress of Castelnuovo, and began to fire upon the citizens. All was confusion in the capital. The Parliament lost more than half of its members, and all its authority. The mob only waited the arrival of the disbanded soldiers to run to plunder and outrage; whilst murderers were let loose upon the most determined patriots, to prevent them from making any effort to retrieve the public fortune. One member, who had the courage to set out for Calabria, in order to rally the broken ranks of the patriots, was put to death upon approaching Eboli, by assassins, who there waited his arrival. Twenty-four other members remained in the Parliament to the last, appealing against perjury and foreign injustice, and offering an honourable but useless example to their country. In a few days, the fortresses, the arsenal, the ammunition, the navy, the capital, Sicily, and whatever yet remained to the nation for its defence, was delivered up to the Austrians by the executive power. Of the patriots, hunted down in all directions, some took shelter in Spain, Greece, and the Ionian Islands, but the greater number fell into the hands of their enemies. The nation, forsaken by its guides, was struck with astonishment, and made no defence.

With regard to the actual state of the Two Sicilies, it is enough to say, that all the injustice and miseries which can fall upon a conquered people, punish their inhabitants for not having better defended their most valuable rights. Oppression, however, cannot consolidate that absolute power, which has no longer a foundation in the national sentiments.

NATIONS, LAW OF.

Ideas involved in the term Law.

In the meaning of the word Law, three principal ideas are involved; that of a Command, that of a Sanction, and that of the Authority from which the command proceeds.

Every law imports, that something is to be done; or to be left undone.

But a Command is impotent, unless there is the power of enforcing it. The power of enforcing a command is the power of inflicting penalties, if the command is not obeyed. And the applicability of the penalties constitutes the Sanction.

There is more difficulty in conveying an exact conception of the Authority which is necessary to give existence to a law. It is evident, that it is not every command, enforced by penalties, to which we should extend such a title. A law is not confined to a single act; it embraces a class of acts: it is not confined to the acts of one man; it embraces those of a community of men. And the authority from which it emanates must be an authority which that community are in the habit of obeying. An authority to which only a temporary obedience is paid, does not come up to the notion of that authority which is requisite to give existence to laws; for thus, the commands of a hostile army, committing plunder, would be laws.

The conditions, which we have thus described, may all be visibly traced, in the laws which governments lay down for the communities to which they belong. There we observe *the command;* there *the punishment* prescribed for its violation; and there *the commanding authority* to which obedience is habitually paid.

These ideas how modified in the term Law of Nations.

Of these conditions how many can be said to belong to any thing included under the term Law of Nations?

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By that term is understood, something which either does, or which, it is supposed, ought to bind the conduct of one nation towards another.

But it is not understood, that one nation has a right to command another. When one nation can be commanded by another, it is dependent upon that other; and the laws of dependence are different from those which we are at present considering. An independent nation would resent, instead of obeying, a command delivered to it by another. Neither can it properly be said, that nations, taken aggregately, prescribe those laws to one another severally; for when did they ever combine in any such prescription? When did they ever combine to vindicate the violations of them? It is therefore clear, that the term Command cannot be applied, at least in the ordinary sense, to the laws of nations.

In the next place, it would not seem, that any thing, deserving the name of Sanction, belongs to them. Sanction, we have already seen, is punishment. Suppose nations to threaten one another with punishment, for the violation of any thing understood to be a law of nations. To punish implies superiority of strength. For the strong, therefore, the law of nations, may perhaps have a sanction, as against the weak. But what can it have as against the strong? Is it the strong, however, or is it the weak, by whom it is most liable to be violated? The answer is obvious and undeniable.—As against these from whom almost solely any violation of the laws of nations need be apprehended, there appears, therefore, to be no sanction at all.

If it be said, that several nations may combine to give it a sanction in favour of the weak, we might, for a practical answer, appeal to experience. Has it been done? Have nations, in reality, combined, so constantly and steadily, in favour of the law of nations, as to create, by the certainty of punishment, an overpowering motive, to unjust powers, to abstain from its violation? For, as the laws against murder would have no efficacy, if the punishment prescribed were not applied once in fifty or a hundred times, so the penalty against the violations of the law of nations can have no efficacy, if it is applied unsteadily and rarely.

On the mode in which it has been applied, we may appeal to a great authority. Montesquieu says—"Le droit public est plus connu en Europe qu'en Asie: cependant on peut dire que les passions des princes—la patience des peuples—la flatterie des ecrivains, en ont corrompu tous les principes. Ce droit, tel qu'il est aujourd'hui, est une science qui apprend aux princes jusqu'à quel point ils peuvent violer la justice, sans choquer leurs intérêts."—(*Lett. Persanes*, XCIV.)

To go a little deeper, we may consider, whether the interest of nations, that which, in the long run, governs them all, can ever produce combinations, from which an effectual sanction, of the nature in question, can be expected to proceed. That they would derive some advantage from the general observation of those maxims which have been called laws of nations, frivolous as are the points upon which the greater part of them turn, cannot be denied. These advantages, however, are seen at a distance, and with the mind's eye; they are speculative, rather than sensible. The inconveniences, on the other hand, which must be felt, from any movement to lend effect to the law of nations, are immediate and formidable; the whole train of the evils of war are almost sure to arise from them. The latter class of impressions must, in general, be far more powerful than the former; and thus the interposition, in favour of the law of nations, will generally be shunned. A nation is often but too easily stimulated to make war in resentment of injuries done to itself. But it looks with too much coolness upon the injuries done to other nations, to incur any great chance of inconvenience for the redress of them.

Besides, the object is to be gained by the means of combination. But the combinations of nations are very difficult things. Nations hardly ever combine without quarrelling.

Again, all nations ought to combine for an object common to all. But for all nations to combine in any one enterprise is impossible. Suppose a prince to have violated the law of nations, it would be absurd to suppose that all the countries on earth should conspire to punish him. But if not all, what is to be the selection? Who shall come forward; who stand excused? By those who are condemned to the sacrifice, in what proportion are the contributions to be made? Who is to afford the greatest, and who may come with the least?

It is unnecessary to pursue any farther the analysis of this extraordinary hypothesis. It is evident from what has been said, that it is full of impracticabilities.

Are we, then, obliged to consider the maxims or rules, which pass under the name of Laws of Nations, as utterly without force and influence; and the discourse which is made about them, as mere affectation and impertinence?

The only sanction applicable to the Law of Nations is the popular sanction.

Not wholly so. It is of use, that the ordinary intercourse of nations should be conducted according to certain forms, generally known and approved; because they will be observed on all occasions, when there is no particular motive to violate them, and will often prevent disputes which might arise on frivolous occasions. They resemble, in this respect, the ceremonial of a court, or the established forms of polished society.

The objects, however, which are understood to be embraced by the law of nations, are of two sorts. The first are those minor objects, which partake more of form than of substance. The other are objects which deeply affect humanity. That there are certain interests of nations, which it were good to have considered as their rights, and of which it is infinitely to be desired that the violation could be prevented, is most true. But if national law has no penalty annexed to it; if the weaker party, who is wronged, has no means of redress, where, it may be said, is the advantage of such a law? Or where the propriety of calling that a law, which is only a declaration respecting rights; violated by the more powerful party with impunity, as often, and to as great an extent, as he pleases?

There is still, however, a power, which, though it be not the physical force, either of one state, or of a

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combination of states, applied to vindicate a violation of the law of nations, is not without a great sway in human affairs; and which, as it is very nearly the whole of the power which can be applied to secure the observation of that law, deserves to be carefully considered, that, by duly appreciating its efficacy in this important affair, we may neither trust to it where it will disappoint our expectation, nor neglect the use of it where it may be turned to advantage.

That the human mind is powerfully acted upon by the approbation or disapprobation, by the praise or blame, the contempt and hatred, or the love and admiration, of the rest of mankind, is a matter of fact, which, however it may be accounted for, is beyond the limits of disputation. Over the whole field of morality, with the exception of that narrow part which is protected by penal laws, it is the only power which binds to good conduct, and renders man agreeable and useful to man. It is evident, also, that where there is not great inequality, it is a power, the binding force of which must be necessarily great. Because every individual, considered in himself, is weak and helpless as compared with the rest of the community. Unless, therefore, he can prevail upon them to abstain from injuring him, he must be exposed to unlimited suffering. And if, on the other hand, he can prevail upon them to combine in doing, or in desiring to do him good, he is put in the way of receiving perpetually the greatest advantages. His motive, therefore, to obtain the favourable, and to avoid the unfavourable regards of the members of the society, in which he lives, is of the highest order. But he can obtain their favourable, and avoid their unfavourable sentiments, only by abstaining with scrupulous anxiety from doing any injury to them, and observing all such modes of conduct as are calculated to be useful and agreeable to them.

The value which men set upon these favourable regards of the persons among whom they live, is strikingly manifested by some of the most ordinary forms of their discourse and behaviour. What is more esteemed than character? What injury reckoned more deep and unpardonable than that of the man who exerts himself to take away unworthily any part of the reputation of his neighbours? But what is character, if not the title to the favourable sentiment of other men? And what is the loss of character, but the opinion of other men, that we do not deserve those favourable sentiments, with which they have been accustomed to regard us?

Honour and shame, those emotions, the intensity of which is proved by so many phenomena of human life, are but the feelings which attend upon those different situations. When a man finds himself in possession of the love, the esteem, and admiration of those by whom he is surrounded, he is filled with that delight which the belief of the secure possession of a great source of benefit, cannot fail to inspire: he is fearless, elated, and confident; the principal characteristics of that state of mind which we denominate pride. When he is conscious, on the other hand, of having forfeited in any degree the favourable sentiments of those among whom he lives, he suffers that depression which the loss of a highly valued possession is calculated to create; he ceases, in some degree, to look forward to his fellow men for good, and feels more or less the apprehension of evil at their hands; he fears to prove how far their disapprobation of him reaches, or to excite them to define it too accurately for themselves; he hangs down his head, and dares not so much as look them in the face.

When men are favourably situated for having those impressions deeply struck; or more correctly speaking, when those combinations of ideas have consistently and habitually been presented to their minds, the association becomes at last so indissoluble and strong, as to operate, even where the connection among the things themselves may not exist.

When persons, who have been educated in a virtuous society, have, from their infancy, associated the idea of certain actions with the favourable sentiments, and all the advantages which flow from the favourable sentiments of mankind; and, on the other hand, have associated the idea of certain other actions with the unfavourable sentiments, and all the disadvantages which flow from the unfavourable sentiments of mankind; so painful a feeling comes in time to be raised in them at the very thought of any such action, that they recoil from the perpetration of it, even in cases in which they may be perfectly secure against any unfavourable sentiments of mankind, which it might be calculated to inspire.

It will, we apprehend, upon the most accurate investigation, be found, that this is the only power to which we can look for any considerable sanction to the laws of nations;—for almost the only species of punishment to which the violation of them can ever become amenable; and the only security, therefore, which mankind can ever enjoy for the benefit which laws, well contrived for this purpose, might be calculated to yield.

What dependence may be placed upon the popular sanction.

It is in the next place incumbent upon us to inquire, what dependence can be placed upon this security, in the set of cases now under consideration; and in what circumstances it is calculated to act with the greatest, in what with the least efficacy, toward this important end.

A power, which is wholly derived, from the good which may follow the favourable, the evil which may follow the unfavourable sentiments of mankind, will act most efficaciously upon him who is the most, least efficaciously upon him who is the least exposed to receive good and evil from the immediate inclination of his fellow men.

It seems to be evident, that he who is most weak, as compared with the rest of the community, is the most exposed to receive good or evil in consequence of their favourable or unfavourable sentiments; and that he, on the other hand, who is the most powerful, as compared with them, is the least exposed to receive good or evil in consequence of those sentiments.

When men are nearly upon equality, no one has any chance of inducing other people to abstain from hurting him, but by his abstaining from doing hurt in any way to them. He has no means of inducing them to do him any acts of service, but by their expectation of receiving similar acts of service from him. He is, therefore, intensely interested in its

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being generally believed of him, that he is a man who is careful to abstain from injuring, and ever ready to exert himself to do services to others.

The case is exceedingly different, where one man is lifted high above others. In that case he has powerful means of protection against their hurtful acts, powerful means of obtaining their services, altogether independent of his conduct, altogether independent of his disposition either to abstain from injuring them, or to render them service.

So far, therefore, as good conduct arises from a man's dependence upon the sentiments of others; and from this is derived the moral power, to which alone the term moral sanction or obligation can properly belong; the security for good conduct is apt to be lessened, in exact proportion as any one is raised above the level of those composing the mass of the community. If any man possesses absolute power over the rest of the community, he is set free from all dependence upon their sentiments. In this, or nearly in this situation is every despot, having a well established authority. So far as a man is educated as a despot, he can therefore have but few of those associations, on which a conduct, beneficent to others, depends. He is not accustomed to look—for the services which he needs, or the evils which he apprehends, from others—to the opinion which they may entertain of the goodness or badness of his conduct; he cannot, therefore, have that salutary train of associations from an evil act to the condemnatory sentiments of mankind, and from the condemnatory sentiments of mankind to the forfeiture of all those delights and advantages which spring to him from the operation of their favourable regards;—associations which in men favourably situated become at last habitual, and govern the conduct, as it were, mechanically, without any distinct recurrence to the consequences, upon the thought of which, nevertheless, this salutary and ennobling sentiment ultimately depends, and from which it has been originally derived.

If such is the situation of the despot with regard to these important associations, it is in a proportional degree the situation of all those who partake of that species of elevation. In an Aristocratical country, for example, a country in which there is great inequality of wealth, those who possess the large fortunes, are raised to a great degree above any chance of receiving evil, or of standing deprived of any good, because the great mass, the lower orders, of their countrymen, think unfavourably of them. They are, no doubt, to a considerable degree dependent upon what the people of their own class may think of them; and it is accordingly found, that those qualities and acts, which are useful to that class, are formed into a particular, an Aristocratical code of morality, which is very effectually sanctioned by the favourable and unfavourable sentiments of the Aristocratical body, at the same time that it is exceedingly different from that more enlarged and all comprehensive code, on which the happiness of the greatest number depends, and to which alone the epithet moral in propriety belongs.

Such being the state of the facts connected with this important case, it remains to see what are the inferences, bearing upon it, which we are entitled to draw from them. We have already ascertained, that the only power which can operate to sanction the laws of nations; in other words, to reward or punish any nation, according as it obeys, or disobeys them, is the approbation and disapprobation of mankind. It follows, that the restraining force is, in this case, determined by the associations which they who govern it may have formed with the approbation and disapprobation of mankind. If they have formed strong associations, of a pleasurable kind, with the approbation, strong associations, of the painful kind, with the disapprobation of mankind, the restraining force will be great; if they have not formed such associations, it will be feeble and insignificant. It has, however, appeared, immediately above, that the rulers of a country, of which the government is either monarchical, or aristocratical, can have these associations in but a very low degree; as those alone, who are placed on a level with the great body of other men, are placed in circumstances calculated to produce them. It is only then in countries, the rulers of which are drawn from the mass of the people, in other words, in democratical countries, that the sanction of the laws of nations can be expected to operate with any considerable effect.

What is required to give to the Law of Nations its greatest perfection.

Having thus ascertained, what is the power which restrains from violating the laws of nations, and what the description of rulers upon whom its restraining force is the greatest, we are next to inquire, by what expedients the force of it may be raised to the greatest pitch, and the greatest amount of benefit may be derived from it.

It is sufficiently recognized, that whatever is intended to produce any effect as a punishment, produces it in a greater degree, in proportion as it operates with greater precision and certainty. The inquiry, then, regards the means of giving precision and certainty to those sentiments of the world, on which the binding power of the laws of nations so greatly depends.

Two things are necessary to give precision and certainty to the operation of laws within a community. The one is, a strict determination of what the law is, the second, a tribunal so constituted as to yield prompt and accurate execution to the law. It is evident, that these two are indispensible requisites. Without them no penalties can operate with either precision or certainty. And the case is evidently the same, whether we speak of the laws which regulate the actions of individual and individual within the state, or those which regulate the actions of one state towards another.

It is obvious to remark, in the first place, that with regard to the laws of nations, not one of these two indispensible requisites has ever yet had any existence. It has neither been determined what the laws in question are, nor has any common tribunal for cognizance of the violations of them ever been constituted. With respect to the last, not so much as the idea of it seems to have been entertained. And with respect to the first, though much has been written, it has been almost wholly in the way of vague

and general discourse. Hardly a single accurate definition has yet been applied to any part of the subject.

Here, then, we come to what is obviously the grand inquiry; namely, *first*, What can be done towards defining the laws of nations? and, *secondly*, What can be done towards providing a tribunal for yielding prompt and accurate decisions in conformity with them? in other words, for applying with the greatest possible efficacy the opinion of the world for restraining the violation of them?

Necessity for a CODE of International Law.

In the Article JURISPRUDENCE, to which it is necessary for us here to revert, we have sufficiently made it appear, that the foundation of all law is the constitution of rights. Of two parties, unless it is previously determined what each shall enjoy, it can never be determined whether one has improperly disturbed the enjoyment of the other. To determine, however, what a party is to enjoy, is to determine his rights.

Now, then, with regard to nations, the question is, what ought to be constituted rights? or in other words, what would it be desirable, for the good of mankind upon the whole, that the several nations should respect as the rights of each other?

This, it is pretty obvious, is one of the most extensive of all inquiries, far exceeding the limits of an article in the present work. We can attempt little more than to show the way in which the inquiry may be carried on.

Rights of Nations.

In the Article JURISPRUDENCE, we have endeavoured to clear up the meaning which in legislation can, without leading to confusion, be alone attached to the term *Rights;* and we have there likewise seen, that there are but two classes of objects, in which individuals can have rights; namely, Things, and Persons.

The case, we believe, will be found the same with respect to nations. They also can have rights, in nothing but Persons, and Things. Of course, it follows, that they can receive injury in nothing but in Persons, or Things.

The inquiry, however, with respect to the rights of nations, is not so simple, as that with respect to the rights of individuals; because between individuals, subject to the same system of laws, the legislature recognizes no state of hostility; but between nations there is the State of War, and the State of Peace, and the rights which are understood to belong to nations are different in these two different states. In the state of war, nations recognize in one another very few rights respecting either persons or things; they kill the one, and take and destroy the other, with little other limit than the want of ability. In the state of peace, they respect as rights belonging to one another, nearly the same things which are constituted rights of individuals, by the ordinary systems of national law.

What should be recognized as Rights in time of Peace.

We shall begin with the consideration of those things which it would be desirable that nations should respect as the rights of one another, in the time of peace.

And, *first*, of rights with respect to things. As the subject of the rights of nations, things may be divided into two sorts; things belonging to some individual member of the nation, and things belonging to the nation in its collective, or corporate, capacity.

The Property of Individuals.

Those rights in things which the nation guarantees to its individual members, within the nation, it would be desirable, with hardly any exception, that nations should respect in regard to one another; that those things, for example, which the government of the country to which a man belongs, would regard, and would compel all its subjects to regard, as his property, the governments of all other countries should respect, and compel all their subjects to respect as his property.

There are two states of circumstances in which questions may arise between nations, respecting the property of their respective subjects. The first, where the property in question, when the cause of dispute arises, is within the country of the individual to whom it belongs: The second, where the property has, by its owner, been previously removed into the country, with which, or some of the inhabitants of which, the dispute has arisen.

1. The first set of circumstances exists between two conterminous countries; the bordering inhabitants of which are neighbours to one another, and may, as any other neighbours, infringe the properties of one another. The proper mode of settling these disputes seems to be sufficiently obvious. The rights of the party complaining should be adjudged, according to the laws of the country to which he belongs. But the party sued or prosecuted, should be amenable only to the tribunals of the country to which he belongs; that is to say, the question should be tried before the tribunals of the country of the defendant; but the definition of the right in question should be taken from the law of the country to which the plaintiff belongs. It might in some cases be convenient for countries in this situation, to agree in constituting a common judicature, appropriated to these disputes, to consist, for example, of two judges, one of each country, with power to chuse a third, when they could not agree.

The injury complained of may be capable of redress by a remedy of the nature of a civil suit merely; or it may be of that more atrocious sort, theft or robbery, for which the remedy of punishment is required.

It would appear that punishment ought to be apportioned according to the laws of the country to which the party who has incurred it belongs. Whatever would be the punishment decreed for the offence, if committed against a man of his own country, such a punishment he ought to sustain, for the offence against the man of the other country. The question of punishment is here understood, as extraneous to that of compensation. This ought always to be made to the party injured, where it is capable of being made, and in a case of property it is always capable; if not by the author of the injury, from want of property, or other cause, at least by the government of the country to which he belongs.

2. Where a man has removed his property from his own into another country, there seems no peculiar reason why it should be regulated by any other laws than those of the country into which he has removed it; why the rights which it confers should be

otherwise determined; or the violation of them otherwise punished.

We have now considered, though in a very general manner (and our limits preclude us from attempting any thing more), the mode in which nations should agree about the rights of one another (in other words, the laws they should establish), in as far as the property of individuals, belonging to them, is concerned. After the *property* of individuals, their *persons* are to be considered as requiring the protection of laws.

The Persons of Individuals.

There is more difficulty in determining what is desirable, as international law, upon this part of the subject, than in that which regards the property of individuals. It is desirable that the persons of the inhabitants of every country should receive protection, according to the laws of their own country. But it is also desirable that each man should sustain punishment according to the laws of his country; and these two objects are to a certain extent inconsistent with one another.

The inconvenience, however, seems to be greater, in permitting the inhabitants of one country to be punished, according to the laws of another; than in leaving the inhabitants of one country to the same measure of protection against injury to their persons from the inhabitants of other countries, as is afforded to the inhabitants of those countries by their own laws. Many cases, indeed, may be conceived, in which this is a measure of protection which all reasonable men would allow to be inadequate. In such cases, however, the only remedy seems to be the formation of a compact, by which a mode of proceeding, agreeable to the sentiments of both parties, may be positively prescribed. This latter expedient is of course extraneous to that equitable construction which ought to be uniformly applied by the tribunals of one country to the injuries perpetrated, by those whom they may have to judge, upon the inhabitants of another country. If an inhabitant of Persia, for example, should force cow-broth down the throat of an inhabitant and native of Hindostan, the tribunals of Persia should not punish this outrage, as they would punish one Persian for making another swallow the same liquid. To the Persian it would be a trifling injury, and more than a trifling punishment would not be required. To the Hindu, it would be one of the greatest of all conceivable injuries. It ought to be, therefore, put upon the same footing, with an injury of an equal degree, done to a Persian; the nature of the injury, not the external act, should be the object of consideration: and whatever the punishment which would be awarded against a Persian for one of the greatest injuries of which he could be guilty to a Persian, the same ought to be inflicted upon him, for this, one of the greatest which he could occasion to a Hindu.

Besides the cases in which a government, as representative of the country, may be injured through the individuals who live under its protection, there are cases in which it may be injured more directly. Certain things belong as property to the government, without belonging to any individual; and there are persons who are members of the government, or agents of the government, and who may receive injuries in that capacity, distinct from those which affect them, as private individuals. These are the cases to which it now remains that we direct our attention.

The Property or Dominion of the State.

Those things which belong to government as goods and chattels; its moveables, for example; or the lands which it holds, as any individual holds them, in the way of an estate; there seems to be no reason for considering as subject to any other rules, than those applicable to the goods and chattels which belong to individuals.

Of other things, those to which any government can claim a right, as representative of a nation, must be, either, first, Portions of Land, or, secondly, Portions of Water.

Dominion in Land.

1. The questions which relate to the rights which any nation may claim in any portion of land, are questions regarding boundaries; and these involve the whole of the questions respecting the acquisition of dominion.

To have any standard for determining questions with regard to dominion, the different modes of acquiring dominion, must be recognized; those which are proper to be allowed and respected by other nations must be distinguished from those which are improper, must be accurately defined, and the definitions made known.

For this purpose it is easy to perceive, that the same process is necessary, as that for the definition of rights, described, at some length, in the Article in this work, entitled JURISPRUDENCE, to which we must again refer.

It is necessary, according to that example, that the events which are to be considered as giving commencement to a right of dominion, and those which are to be considered as putting an end to it, should be fully enumerated, and accurately defined.

This is the first part of the process. The other part is, to distinguish the different degrees of dominion. There is a dominion which is perfect, which includes every power over the subject in question, and leaves nothing farther to be acquired, a *dominium plenum:* there is also a dominion, which is but the commencement, as it were, of dominion, and includes the smallest possible fragment of a full dominion. These are the two extremes; and between them are various distinguishable degrees. All these should be fully depicted, and accurately defined.

When any of those events occurs which are to be considered as giving commencement to rights, it often happens that they are accompanied by circumstances which limit the right they would otherwise convey, and render the dominion less than full. These circumstances ought, also, to be completely enumerated; and the power of each to be accurately defined.

If this were done, an international code would be composed, in which the rights of dominion would be accurately defined; and to determine any question about boundaries, or about the degree of dominion, nothing farther would then be necessary than an adequate inquiry respecting the state of the facts.

The questions would exactly resemble those, which we have already described, in the Article JURISPRUDENCE, in analyzing what is called pleading in ju-

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dicature. In a question about boundaries there is, let us suppose, a district, over which one country affirms that it has a right of dominion, a dominion more or less complete; and another country denies that it has that right. The first question is, Whether any of those events has occurred, which would give the affirming country a right of dominion? The second question is, Whether, if such an event had occurred, it was accompanied with any of those circumstances which limit dominion, and render it less than full, and if so, under what degree of limiting power they are classed? The third question is, Whether, if an event, thus giving commencement to a right of dominion had occurred, any other event, putting an end to that right, had subsequently occurred?

We need not here enlarge upon these several topics; because they will be sufficiently understood by those readers who bear in mind the expositions already given in the article referred to; and to those, who do not, we suggest the propriety of recurring to that article, as a preparation for the perusal of this.

It is evidently disproportionate to the limits which we must here prescribe to ourselves, to enumerate the events which it would be agreeable to the interests of mankind in general, that nations should regard as giving, and alone giving, commencement and termination to rights of dominion; because, in order to afford an enumeration which would be in any degree instructive, the reasons must be given why one set of events, and not another, should have the privilege in question conferred upon them.

It may be proper, however, in the mean time, to observe, that the events in question will not be found to be numerous, nor very difficult to discover. In fact, they are, and among civilized nations, almost always have been, pretty nearly agreed upon; and they are the questions of modification, and questions of fact, upon which, chiefly, differences have arisen. For example, there is no dispute, that Occupancy, where there is no prior right, is an event which should be considered as giving commencement to a right of dominion. Neither is there any doubt, that the Consent of those who have a right, may transfer that right to others: or in other words, that such consent is an event which gives commencement to a right in those others. Conquest, also, made in a lawful war, is recognized as an event of the same description; and, it will be found upon inquiry that these do, in fact, contain the whole. For on every occasion on which dominion is acquired, the territory so acquired must, before hand, either have belonged to some body, or have belonged to no body. If it belonged to no body, occupancy is the only event which can be supposed to give commencement to the right. If it belonged to some body, it must be taken from him, either willingly, or by force. If it is taken from him willingly, we have his consent. If it is taken by force, it is by conquest in war, that the new right is created.

It is evidently, however, farther necessary, that the different species of consent should be distinguished; and those to which it would be proper to attach this investitive power, separated accurately from those from which it should be withheld. It is here accordingly, that the doctrine of contracts, would need to be introduced; that the different species of them applicable to this subject, in which all treaties would be included, should be enumerated; that the effects proper to be given to each of them should be defined; and the mode of interpreting them, or fixing the sense which they ought to bear, accurately laid down.

It would also be expedient, after the principal contracts, applicable to international concerns, are ascertained, to exhibit in the international code, *formulæ*, with blanks to be filled up, which should be employed by nations on all occasions of such contracts, and being framed with the greatest possible accuracy, would go as far as it would be possible by words to go, in excluding ambiguity, and the grounds of dispute.

With respect to conquest, the last event, calculated to give commencement to rights of dominion, mentioned in the above general enumeration, it is allowed, that as there are some conquests which ought not to be considered as conferring rights of dominion, there are others which ought to be considered as doing so. It is evidently necessary, therefore, that the line of separation should be drawn.

Whether a conquest, however, should or should not be considered as conferring a right of dominion, depends very much upon the nature of the war, through which it is made. If the war be what is regarded as just, and the mode of warfare conformable to the recognized rules, the conquest is apt to be regarded as conferring a legimate title; if the war, and mode of war, be of a contrary description, the validity of the title conferred by the conquest may be liable to dispute.

It is evident, therefore, that in order to define the species of conquest on which the investitive power in question should be conferred, the circumstances which render a war justifiable, and the mode in which it is justifiable to carry it on, must first be ascertained. This forms the second part of our inquiry: and the question regarding the investitive power of conquest must be deferred, till that inquiry is performed.

Having thus far considered the mode in which should be determined the rights which nations acquire over portions of territory, or Land, it remains that we consider the mode in which their rights should be determined with regard to Waters.

Dominion in Water.

Waters, as concerns the present purpose, are, either rivers or the sea.

As the sea involves the questions of greatest extent and importance, we shall attend to that part of the subject first.

Even in the language of ordinary discourse, the sea is denominated the common domain of nations.

The first principle with regard to the sea is this, that all nations have an equal right to the use of it. The utility of recognizing this principle, is so apparent, that it has never been the subject of any dispute. And all the rights assigned to nations severally, in the enjoyment of this common domain, ought to rise out of this principle; and to be limited by it. Whatever use any nation makes of it, should be such as not to prevent a similar and equal use from being made by other nations. And every use which can-

not be shown to have that effect, should be recognized as a right by the law of nations.

The principal use which nations make of the sea, is that of a passage for their ships. Agreeably to the principle which we have recognized, the ships of one nation should pass in such a manner as not to obstruct the passage of those of another. The rules according to which the possible cases of interference should be regulated, are very simple; and are, in fact, laid down and acted upon, with considerable accuracy. They resemble, in all respects, those according to which the vessels of the same country are made to avoid and to regulate their interferences in the rivers of the country, or upon its coasts. There would be no difficulty, therefore, in making accurate definitions of the requisite rights, for insertion in the international code.

The rights being established, the violations of them should be punished, on the same principles, as those which we have laid down in regard to the preceding cases. Either property has been injured, or persons. In either case, compensation is an indisputable part of the remedial process, wherever it is practicable. In loss of property, it is fully practicable. It is also practicable in many of the injuries done to the person. As in the case of offences committed on land, the rights of the individual who has suffered should be estimated according to the laws of the country to which he belongs; but the punishment of the offender should be measured according to the laws of the country to which he belongs. In the case of piracy, which is robbery, or murder, committed by persons whom no country recognizes, and upon whom, therefore, justice can be demanded from no foreign government, it has hitherto been the practice that the nation suffering has taken the punishment into its own hands. Accordingly, the punishment of piracy has always been extremely severe. It would be, no doubt, better, if a mode were adopted, by which it would not be necessary for a nation to be judge in its own cause. A rule does not seem impossible to be framed, according to which the punishment of piracy might be provided for, by referring those accused of it, either to some general tribunal, constituted for that purpose, or to the tribunals of some nation other than that against which the offence has been perpetrated. A general law, on this subject, to be observed by all nations, would be highly desirable.

Rules, therefore, seem not difficult to be laid down, for regulating the proceedings of nations on the high seas. A distinction, however, is drawn between what is called the *high*, and what is called the *narrow seas*. By the narrow seas is commonly meant some portion of sea, to a greater or less extent, immediately surrounding a particular country; and in which that country claims peculiar privileges. The question is, whether any such privileges should be allowed, and if allowed, to what extent?

The regulating principle in this, as in other cases, is the general advantage, the principle of utility. There are cases, in which certain privileges, in the waters surrounding a particular country, are of so much importance to that country; and the exercise of those advantages occasions so very little inconvenience to other nations, that what is lost, by all of them taken together, bears no comparison with what is gained by that particular nation. In these cases, the exercise of such privileges should be allowed; they should, however, be defined, in as many instances as possible, and promulgated by insertion in an international code.

Of the privileges in question, are all those which are essential, or to a considerable degree subservient, to the national security. In some cases, the exclusive right of fishing might perhaps come under the same rule. But this is in general provided for, by the necessity of drawing the nets, or curing the fish upon the land, a privilege which, of course, it is in the power of any nation to give or to withhold.

In obedience to this equitable principle, it appears, that such foppish privileges, as have sometimes been insisted upon, and afford no advantage to one nation, which is not wholly at the cost of others—lowering the flag, for example, and such like impositions—should not be recognized by the code of nations.

It appears, also, that those tolls which have been, sometimes, and are levied at the narrow inlets of some seas, deserve to fall under the same condemnation. The passage through these inlets is a common good to all the nations of the earth which may have a motive to use them; a good of the highest importance to the nations which are situated within, and to which it is the only means of maritime communication; and, while it imparts no evil to the conterminous nation, the toll which that nation levies is an advantage obtained wholly at the cost of others; and imposing upon them a burthen, in the way of obstruction and trouble, which is compensated for by advantage to nobody.

The waters, we have said, in respect to which rights should be assigned to nations, are rivers and the sea. Having stated what appears necessary on the present occasion with respect to the sea, it remains that we offer the few observations required, on the subject of rivers.

Rivers are either the boundary between two countries, or they are wholly within a particular country.

Those which are wholly within a particular country, it seems most agreeable to the principle of utility to regard as wholly belonging to that country. In the case of navigable rivers which pass through several countries, it would indeed be desirable for those countries which are situated higher up than that at the mouth of each, as well as for all those who might thus have intercourse with them, that the navigation of such rivers should be free; but it would be difficult so to regulate this right, as not to affect the security of the country through which a free navigation should thus be allowed; and a slight diminution in its security would be so great a loss to that country as would require, to compensate for it, a very great advantage to those by whom the navigation was enjoyed. Unless where this advantage were very great, it would not, therefore, be agreeable to the principle which should dictate the laws of nations, that the freedom of the navigation should be regulated on any other principles than those of mutual agreement.

In regard to those rivers which flow between two

countries, the principle of regulation is sufficiently plain. The benefits derivable from the river should be shared equally between them. Its principal benefits arise from the fishing and from the navigation. The right of fishing in most cases may be fitly distributed, by each party fishing from its own bank to the middle of the stream. The right of navigating of each must be so exercised as not to obstruct the right of the other. In this case the same sort of rules are required, to prevent the ships of the two nations from obstructing one another, in a common river, as are found available to prevent the ships of different individuals from obstructing one another, in a river belonging to one country. There is no difficulty, therefore, here, which it is worth stopping to show how to remove.

What should be recognized as Rights in time of War.

We have now adduced, what our limits admit to be said, upon the first great branch of the inquiry relative to the law of nations; namely, the rights which they should recognize in one another in the state of peace. We proceed to the second branch, relating wholly to the state of war.

The questions which present themselves for solution relating to the state of war, are either those which respect its commencement, or those which respect the mode of carrying it on.

What should be regarded as necessary to render the commencement of a War just.

With respect to the commencement of a war, the principal question is, What are the conditions which should be regarded as necessary to render it just?

As men, in a situation where laws, and the protection derived from them, do not exist, are left to their own protection, and have no means of deterring other men from injuring them, but making them dread injury in return, so nations, which, with respect to one another, have, as we have seen before, but little protection from the legal sanction, are left to supply its place by this dread of injury in return, which, in the case both of individuals and of nations, may be called the *retributive sanction*, and of which, in the case of nations, war is the principal organ.

From this view of the essence and end of war, we lay down immediately one pretty extensive proposition with regard to the conditions necessary to render it just.

As the legal sanction, or punishment for the offences of individuals ought to operate only where some right has been violated, and the violation has been such as to require it, so the retributive sanction of nations, which is war, ought to operate only where some right of the nation, or something which ought to be treated as a right, has been violated, and where the violation has been such as to require that desperate remedy.

But as not all violations which may possibly be committed of the rights of a nation will justify it in inflicting war, the next object is, to draw the line of separation, and distinguish between those violations of the rights of nations which justify, and those which do not justify, the extremity of war.

As the evils which war produces are exceedingly great, it is, first of all, evident, that no violation of rights which is not very great, will, upon the principle which we have so often recognized, suffice to justify it. Of two evils, the least, is the choice of all sound legislation.

Of the violation of the rights of individuals, in the same country, the cases meet for punishment are capable of being pointed out, with a degree of accuracy, not wanting much of perfection. Of the violation of the rights of nations, committed by one nation against another, the cases which would justify the remedial operation of war are much more difficult to define. The difficulty, indeed, is not universal; for there are cases which may be very satisfactorily defined; and as far as definition can go, it is of the utmost importance that it should be carried. Uncertainty, then, pervades only one part of the field; which the more we are able to lessen, the greater the advantage in favour of humanity which we gain. If a proper code of international law were formed, there would be certain defined violations of the rights of nations which would be pointed out, not only as deserving the indignation and hatred of all the world, but as justifying the injured nation before all the world, in inflicting upon its injurer the calamities of war. There would also be certain other injuries pointed out, of a more doubtful character; which might, or might not, according to circumstances not easy to define, be such as to justify recourse to war. The injuries of this secondary character, also, which might, or might not, according to circumstances, justify a war, are capable of being pointed out with a certain degree of accuracy. To a certain degree, likewise, the circumstances which would convert them into justifying causes, are capable of being foreseen. So far definition is capable of extending, and so far, of course, it ought to be carried.

In illustration of this latter class of injuries, we may select the most remarkable, perhaps, and important of all the instances; preparations for a threatened attack. A sense of security is one of the most valuable treasures of a nation; and to be deprived of that sense of security, is one of the greatest of injuries. But what state of preparation shall, or shall not be considered as justifying the threatened nation in striking the first blow, in order not to give its enemy the advantage of completing his preparations, and making his attack just at the moment when it would be most destructive, it is perhaps impossible to determine, for all cases, beforehand; though, no doubt, a certain progress may be made towards that determination, and the bounds of uncertainty may be greatly reduced.

We are aware how general, and therefore how unsatisfactory, these observations are, on the important subject of defining those violations of the rights of nations which ought to be regarded as justificatory causes of war; but at the same time it is to be observed, that not much more could have been done without framing the code, by actually enumerating and defining the violations for which that remedy should be reserved.

Another consideration is now to be weighed. It is evident that whatever injuries are done by one nation to another, compensation may almost always be made for them. It is equally evident, that whatever injury may have been sustained, if compensation is made for it, the justificatory cause of war is removed.

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The doctrine of compensation, therefore, is an important part of international jurisprudence. Before recourse is had to war, for any violation of rights, compensation ought first to be demanded; and no war, except in cases fit for exception, should be regarded as just, which this demand had not preceded; a demand which should be made through a constituted organ, and in a predetermined mode, as we shall more fully describe in a subsequent page, when we come to treat of an international tribunal.

As there can be no reason why the demand of compensation should not always precede the use of arms, except in cases of such a necessity as will not allow time for demanding compensation—a necessity for the immediate use of arms, in order to prevent an evil immediately impending—those cases of urgent necessity should, as far as possible, be sought out, and defined.

Other circumstances may be enumerated, as belonging to this first stage of the remedy, against a nation, which places itself in an attitude, affecting the sense of security of any of its neighbours. If a nation is making preparations, or executing any other measures, calculated to excite alarm, it may be called upon to desist from them; or it may be called upon to give security, that it will not make a hostile use of them. Of these securities, hostages are one of the most familiar instances. Various other instances will easily present themselves to the consideration of our readers. Upon this part of the subject, therefore, it is unnecessary for us to enlarge.

What should be regarded as just and unjust in the modes of carrying on a War.

It thus appears, that we may lay down, with a considerable degree of precision, the conditions upon which the commencement of a war ought to be regarded as just. It remains, under this head of inquiry, that we show how it may, as far as possible, be determined, what ought to be regarded as just and unjust in the modes of carrying it on.

This is an inquiry of more complexity, a good deal, than the first. In looking out for a guiding principle, it is evidently necessary to keep in view the end to which every just war is of necessity restricted. That is, compensation for an injury received, and security that a fresh injury shall not be committed. Combining this with the grand principle of humanity and utility, in other words, of morality; namely, that all evil, wilfully occasioned, and not calculated to produce a more than equivalent good, is wicked, and to be opposed, we obtain one comprehensive and highly important rule; which is this: That in the modes of carrying on war, every thing should be condemned by the law of nations, which, without being more conducive, or more in any considerable degree, to the attainment of the just end of the war, is much more mischievous to the nation against whom it is done.

As the end is to be gained, in most cases, only by inflicting a loss of men and property, upon the opposing nation, it would be desirable that the distinction should be drawn between the modes of inflicting this loss, which are the most, and those which are the least calculated, to inflict pain and suffering, without being more conducive to the end.

One distinction is sufficiently remarkable; namely, the distinction between the men who are in arms or actually opposed to the designs of the belligerent, and the men who are not so; also between the property which belongs to the government of the opposing nation, and that which belongs to private individuals composing the nation.

With respect to the first class of objects, the men in arms, and the property of the government, there is not much difficulty. To produce the loss of them, as rapidly as possible, till the end or purpose of the war is obtained, appears to be a privilege which cannot be separated from the right of warring at all.

With respect to the loss of the men, indeed, there is an important restriction. It means the loss of them for the purposes of the war, and no more. If it be practicable to put them in a situation in which they can no longer be of any service to the war, all farther injury to them should be held unjustifiable. Under this rule falls the obligation, so generally recognized, of making our enemies, as often as possible, prisoners, instead of killing them, and of treating them with humanity, while retained in that condition.

That part of the subject, therefore, which relates to men in arms, and to such property as belongs immediately to the government, it is not impossible to include in rules of tolerable precision. The difficulty is, with respect to those individuals who, composing the body of the nation, form no part of the men in arms, and with respect to the property of such individuals.

Though it would not be correct to say, that these do not contribute, or rather that they may not be made to contribute, to the means with which the government carries on the war; yet it would be absurd not to recognize a very broad distinction between them, and the men and things which are immediately applied, or applicable to the war. A difference, therefore, equally broad, ought, in reason, to be made in the mode of treating them. The mode of treating the one ought to be very different from that of treating the other. As the rule of destruction must be the rule with regard to the first, only limited by certain restrictions; so the rule of forbearance and preservation ought to be the rule with regard to the latter, only to be infringed upon special and justifying circumstances.

Thus far we seem to have travelled with the advantage of light to our path. We may go a little farther, with equal certainty, and say, that as far as regards the persons of those who are not engaged in the immediate business of hostility, very few occasions can occur, in which it would be allowable, upon any just principle of international law, to do them any injury. Leaving them out of the question, we narrow it to the case of the property belonging to individuals; and shall now proceed to see how far the protection of it can be embraced within general rules.

We must suppose the case, which is the strongest, that of an invading army. The advantage which is capable of being derived to such an enemy, by seizing and destroying the property of individuals, bears, unless in certain very extraordinary instances, no sort of proportion, to the evil inflicted upon the individuals. This, we presume, cannot admit of a dispute. Upon the principle, therefore, so often recognized,

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as that, the dictates of which ought in this affair to be solely obeyed, no such destruction, unless in such instances, ought to be sanctioned by the law of nations. Such property, it is well known, can rarely be counted upon, as any considerable resource; because it is to a very great extent in the power of the people invaded to drive their property away, or to destroy it. The property of individuals, in an invaded country, would in general be a much more certain resource to an invading army, if that army were to purchase from them the articles which it desired. And, perhaps, this would be the most advantageous compromise of which the circumstances admit; namely, that the invading army should abstain from the violation of private property; but that it should in return have the benefit of an unrestricted market; that nothing should be done on the part of the government of the invaded country to prevent its subjects from buying and selling with the invaders, as they would with any other parties.

It may no doubt be true, that the plunder and devastation of a province, or other portion of a country, must have an effect in diminishing the resources of the government for carrying on the war. In this point of view it must be allowed that the destruction of private property is of some importance to the invading nation with regard to the result of the war. But the question, in settling the difficulties of international jurisprudence, is not whether an advantage is gained, but whether the advantage, such as it is, be not gained, at too great a cost of evil.

If it be certain that the losing party, in consequence of the destruction in question, loses more than the gaining party gains, it is certain that the two parties, taken together, are losers by the proceeding; and of course that nations, in the aggregate, are losers upon the whole. Nay, it is certain that each nation, taken by itself, is a loser, upon the balance of the cases in which it is liable to lose, and those in which it is liable to gain. If it loses more in the cases in which it bears, than it gains in the cases in which it inflicts invasion; and if it is as liable to bear, as to inflict, which is the usual condition of nations, it follows clearly that it is its interest to concur in a rule which shall protect the property of individuals, in cases of invasion.

Even in that more civilized mode, which has been adopted by invading armies, of availing themselves of the property of individuals; by exacting contributions through the instrumentality of the local authorities; contributions which these authorities are left to partition among the people, as they may deem equitable; though it is admitted that this is a much less hurtful proceeding than military rapine, still we think, it will easily appear, that the evil inflicted upon the contributors is greater than the benefits derived to the receivers.

Unless the amount thus received by an invading army is very considerable, the benefit which is derived, the aid which is gained towards accomplishing the end of the war, must be considered as trifling. But if a contribution, the amount of which can be of any considerable avail towards attaining the object of the war, is levied suddenly upon a particular district, a comparatively small portion of the invaded country, it must operate upon the contributors with a dreadful weight of oppression. Upon an equitable estimate of the circumstances, it can, therefore, hardly fail to appear, that, whether the contribution exacted is heavy or light (it must always be heavy to those who sustain it), the loss to those who suffer must greatly outweigh the advantage to those who receive. If it be so, this mode of exaction should, it is evident, be forbidden by the law of nations.

If these are the principles, upon which an international code, regarding this branch of the subject, ought to be constructed, they will enable us to determine the question with regard to the property of individuals in another set of circumstances, to which the rules of civilized society have hardly yet begun to be applied. Whatever rules apply to the property of individuals found upon the land, the same rules ought, by parity of reason, it should seem, to apply to it when found upon the sea.

The conduct of nations, however, has hitherto not been conformable to the parity which appears to belong to the two sets of cases. Some tenderness, more or less, according to the progress in civilization, appears to have been shown, by all but savages, to the property of individuals upon the land. To this hour the property of individuals upon the sea is made prize of without mercy by the most civilized nations in the world.

The notions of piracy, in fact, have, on this subject, unhappily prevailed, and governed the minds of men. Pirates make prey of every thing. Sailors, originally, were all pirates. The seafaring state was a belligerent state, of almost every vessel against every other vessel. Even when nations had gradually advanced into a more civilized state, and when their vessels abstained from injury to one another in a period of peace, they appear, when the ties of peace were dissolved, and they were placed with respect to one another in a state of war upon the seas, to have felt the force of none but their old associations, and to have looked upon the state of war as a state of piracy. Two nations at war with one another continue to act towards the property of individuals belonging to one another, exactly as two nations of pirates would do.

Assuredly this is a state of things to which the present intelligence and morality of the world ought speedily to put an end. The very same reasoning which we have applied to the case of the property of individuals upon the land, is not less conclusive when applied to the property of individuals upon the sea. The loss to the party losing is more than an equivalent for the gain to the party that gains.

There is another consideration of great importance. All nations gain by the free operations of commerce. If then we were to suppose that the losses and gains of the two belligerent parties balanced one another, which yet they never do, there is an advantage derived from their commerce to every nation on the earth to which, in any degree, either directly or indirectly, that commerce extends; which advantage is either lost or diminished, by their preying upon the property of the individuals belonging to one another. This, therefore, is an unquestionable balance of loss, to the general community of na-

tions, which the law of that community ought to endeavour to prevent.

If, then, we should suppose that it were enacted as the law of nations, that the property of individuals passing on the seas should be equally respected, in peace and in war, we may proceed to consider whether any disadvantage, nearly countervailing the general good, would thence accrue to the belligerents.

It may be alleged, that a nation at war with another is retarded in reducing its antagonist, by the riches which the commerce of that antagonist, if undisturbed, will place at its disposal. But it is evident that an advantage to one of two antagonists, when compensated to the other, by a power to overcome that advantage, exactly equivalent, is in reality no advantage at all. Such is the case with the advantage accruing to the nation with which another is at war, when the property of individuals upon the sea is allowed to pass unmolested. If its riches are increased by freedom of commerce, so are those of its antagonist. The advantages are equal, where the circumstances are equal, which, in the majority of cases, they undoubtedly are.

If it be still objected, that there may be cases in which they are not equal, the answer is obvious, and incontrovertible. There is no general rule without its exceptions, but partial evil must be admitted for general good. Besides, if the case were very remarkable, it might be excepted from the general rule.

If this were adopted as part of the law of nations, all those questions respecting the maritime traffic of *Neutrals*, questions which have been the source of so much troublesome inquiry, so much animosity, and so much mischief, would be immediately at an end. If the traffic of the belligerents, so far as concerned the property of individuals, were free, so would be that of all neutral nations.

Places actually blockaded, that is surrounded with an hostile force for the immediate purpose of being reduced, either by arms, or by famine, would still form exceptions; because the admission of ships into them, with supplies either of food, or munition of war, would be directly at variance with the very object of the blockade.

In all other cases, the admission either of provisions or of instruments of war into a belligerent country, ought, undoubtedly, upon the principle of utility, not to be disturbed. The benefit, except in rare and remarkable cases, could not be material to the country into which they might enter, nor hence the injury to its antagonist; on the other hand, that antagonist would enjoy the same privilege of the free admission of those commodities, and thus they would be equal in all respects. The inconvenience, however, which would thus be saved to the neutrals—the annoyance of search, the loss by detention, the occasions of quarrel—are known to be evils of no ordinary magnitude.

The desertion of sailors from the ships of a belligerent to those of a neutral has given rise to disputes in one instance only, that of Great Britain and the United States of America. The question to be determined, in laying down the principles of international jurisprudence, is, whether this desertion ought to be considered as constituting a ground for the general right of search; in other words, whether the evil to which a belligerent is exposed by desertion, or rather by that portion of desertion which can be prevented by the right of search, is an equivalent for all the evil which is unavoidably produced by it.

Desertion must take place either from the ships of war of the belligerent, or from its merchant ships.

In respect to ships of war, it is so easy for a belligerent to prevent desertion to neutrals, at least in any such degree as to constitute a great evil, that it would be altogether absurd to speak of it as an evil to be compared with those arising from the right of search. The only occasions on which ships of war can be exposed to desertion to neutrals, must be, on those occasions on which they go into a neutral port. But on those, comparatively rare, occasions, they can so easily take precaution against desertion, that the danger to which they are exposed is hardly worth regarding.

When the sailors belonging to merchant ships transfer their services to the ships of a neutral, it is not to be called desertion. It can only take place, in very considerable numbers, when seamen's wages in the neutral country are much higher than in that of the belligerent. The sailor, in this case, leaves his own for another country, only because he improves his situation by so doing. This is a liberty, which, as it ought to belong to every body, so it ought not to be withheld from the sailor. If, indeed, any nation thinks proper to forbid any class of its people to leave their country, as England with regard to its artificers, other countries cannot help that, but they ought not to be called upon to lend their aid to such an antisocial regulation, by allowing their vessels to be searched, as security against its infringement. Besides, it is evident, that there is a much greater security, arising from the very nature of the case, against the chance of a nation's being, to any considerable degree, deprived of its sailors by any such means. If the sailors go into the neutral country because wages are higher there, a small number only will have gone, when wages, from diminution of the numbers, will begin to rise in the country which they have left, and from increase of the numbers, will begin to fall in the country to which they have been tempted to repair. When the wages of seamen have thus sufficiently risen, in the belligerent country, which they are sure to do if the demand for them rises, the sailors will not only come back from every country in the world, but the sailors of other countries will hurry along with them; and the evil of desertion cures itself.

Only two questions, of any great importance, appear to remain; that relating to the march of troops, for a hostile purpose, through a neutral country, and that relating to the extent to which the operations of a successful war ought to be pursued.

According to the principles which we have already laid down for regulating the proceedings of a hostile army even in the invaded country, namely, that of committing no plunder, and enjoying the right of market, it appears that the right of passing through a neutral country on similar terms should be refused to no party. This rule, while it holds out equal advantages to all belligerents, admits, less than any other rule, grounds of dispute.

The end, which we have already described as that alone the pursuit of which can render any war justifiable, sufficiently defines the extent to which the operations of a successful war ought to proceed. The end of every justifiable war is to obtain compensation for an injury sustained, and security against the repetition of it. The last point, that of security, alone contains any uncertainty. Nations are apt to exaggerate the demand for security, to require too much; very often unconsciously, from the mere cravings of self-love; sometimes fraudulently, as a cover for ambitious views. As the question, however, respecting what may or may not, in each instance, be sufficient security, is a question of fact, not of law, it must be determined, if determined at all, by a tribunal empowered to take cognizance of the facts.

Of the construction of an International Code, and an International Tribunal.

We have now then laid down the principles by which, in our opinion, the rights of nations, in respect to one another, ought to be determined; and we have shown in what manner those principles should be applied, in order to come to a decision, in the most remarkable cases. The minor points it is, of course, not in our power to illustrate in detail; but that will not, we should hope, be difficult, after the exemplification exhibited, and the satisfactory solutions at which we seem to have arrived, of all the more considerable questions which the subject presents.

From what has been shown, it is not difficult to see, what would be the course pursued by nations, if they were really actuated by the desire of regulating their general intercourse, both in peace and in war, on the principles most advantageous to them all.

Two grand practical measures are obviously not only of primary importance toward the attainment of this end, but are of indispensable necessity toward the attainment of it in any tolerable degree. These are, first, the construction of a Code; and, secondly, the establishment of a Tribunal.

It is perfectly evident, that nations will be much more likely to conform to the principles of intercourse which are best for all, if they have an accurate set of rules to go by, than if they have not. In the first place, there is less room for mistake; in the next, there is less room for plausible pretexts; and last of all, the approbation and disapprobation of the world is sure to act with tenfold concentration, where a precise rule is broken, familiar to all the civilized world, and venerated by it all.

How the nations might concur in framing an International Code.

How the nations of the civilized world might concur in the framing of such a code, it is not difficult to devise. They might appoint delegates to meet for that purpose, in any central and convenient place; where, after discussion, and coming to as full an understanding as possible upon all the material points, they might elect some one person, the most capable that could be found, to put these their determinations into the proper words and form, in short, to make a draught of a code of international law, as effectually as possible providing for all the questions, which could arise, upon their interfering interests, between two nations. After this draught was proposed, it should be revised by the delegates, and approved by them, or altered till they deemed it worthy of their approbation. It should then be referred to the several governments, to receive its final sanction from their approbation; but, in the mean time, it should be published in all the principal languages, and circulated as extensively as possible, for the sake of two important advantages. The first would be, that, the intelligence of the whole world being brought to operate upon it, and suggestions obtained from every quarter, it might be made as perfect as possible. The second would be, that the eyes of all the world being fixed upon the decision of every nation with respect to the code, every nation might be deterred by shame from objecting to any important article in it.

As the sanction of general opinion is that upon which chiefly, as we have already seen, such a code must rely for its efficiency, not a little will depend upon the mode in which it is recognized and taught. The recognition should in each country have all possible publicity and solemnity. Every circumstance which can tend to diffuse the opinion throughout the earth, that the people of each country attach the highest importance to such a code, is to themselves a first-rate advantage; because it must be of the utmost importance to them, that all the nations of the earth should behave towards them upon the principles of mutual beneficence; and nothing which they can do can have so great a tendency to produce this desirable effect, as its being generally known that they venerate the rules which are established for its attainment.

If nations, then, were really actuated by the desire of regulating their mutual intercourse upon principles mutually beneficent, they would adopt measures for having a code of international law constructed, solemnly recognized, and universally diffused and made known.

But it is not enough that a code should exist; every thing should be done to secure a conduct conformable to it. Nothing is of so much importance for this purpose as a tribunal; before which every case of infringement should be tried, the facts of it fully and completely explored, the nature and degree of the infringement ascertained; and from which a knowledge of every thing material to the case should be as rapidly as possible diffused through the world; before which also all cases of doubt should regularly come for determination; and thus wars, between nations which meant justly, would always be avoided, and a stigma would be set upon those which justice could not content.

The analogy of the code, which is, or ought to be, framed by each state for regulating the intercourse of its own people within its own territory, throws all the illustration which is necessary upon the case of a tribunal for the international code. It is well known, that laws, however carefully and accurately constructed, would be of little avail in any country, if there was not some organ, by means of which it might be determined when individuals had acted in conformity with them, and when they had not; by which also, when any doubt existed respecting the conduct which in any particular case the law required, such doubt might be authoritatively removed, and one determinate line of action prescribed. Without this, it is sufficiently evident, that a small portion of the benefit capable of being derived from laws would actually be attained. It will presently be seen how much

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of the benefit capable of being derived from an international code must be lost, if it is left destitute of a similar organ. We shall first consider in what manner an international tribunal might be constructed; and, next, in what manner it might be appointed to act.

How an International Tribunal should be constructed.

As it is understood that questions relating to all nations should come before it, what is desirable is, that all nations should have equal security for good judicature from it, and should look with equal confidence to its decisions.

An obvious expedient for this purpose is, that all nations should contribute equally to its formation; that each, for example, should send to it a delegate, or judge. Its situation should be chosen or its accessibility, and for the means of publicity which it might afford; the last being, beyond comparison, the advantage of greatest importance. As all nations could not easily, or would not, send, it would suffice if the more civilized and leading nations of the world concurred in the design, with such a number of the less considerable as would be sure to follow their example, and to be desirous of deriving advantage from an instrument of protection, which to them would be of peculiar importance.

As it is found by specific experience, and is, indeed, a consequence of the ascertained laws of human nature, that a numerous assembly of men cannot form a good judicatory; and that the best chance for good judicial service is always obtained when only one man judges, under the vigilant eyes of interested and intelligent observers, having full freedom to deliver to the world their sentiments respecting his conduct; the whole of these advantages may be obtained, in this case, by a very effectual expedient. If precedent, also, be wanted, a thing which in certain minds holds the place of reason, it is amply furnished by the Roman law; according to which a great number of judges having been chosen for the judicial business generally of the year, a selection was made out of that number, according to certain rules, for each particular case.

Every possible advantage, it appears, would be combined in the international tribunal, if the whole body of delegates, or judges, assembled from every country, should, as often as any case for decision came before them, hold a conference, and, after mature deliberation, choose some one individual of their body, upon whom the whole duty of judge should, in that case, devolve; it being the strict duty of the rest to be present during the whole of his proceedings, and each of them to record separately his opinion upon the case, after the decision of the acting judge had been pronounced.

It would be, no doubt, a good general rule, though one can easily foresee cases in which it would be expedient to admit exceptions, that the judge, who is in this manner chosen for each instance of the judicial service, should not be the delegate from any of the countries immediately involved in the dispute. The motive to this is sufficiently apparent.

We apprehend, that few words will be deemed necessary to show how many securities are thus provided for the excellence of the judicial service.

In the first place, it seems impossible to question, that the utmost fairness and impartiality are provided for, in the choice of the judge; because, of the two parties involved in the dispute, the one is represented by a delegate as much as the other, and the rest of the delegates are indifferent between them. In general, therefore, it is evident, that the sinister interest on the two sides being balanced, and there being a great preponderance of interest in favour of nothing but a just decision, that interest will prevail.

The best choice being made of a judge, it is evident that he would be so situated, as to act under the strongest securities for good conduct. Acting singly, he would bear the whole responsibility of the service required at his hands. He would act under the eyes of the rest of the assembled delegates, men versed in the same species of business, chosen on account of their capacity for the service, who could be deceived neither with respect to the diligence which he might exert, nor the fairness and honesty with which he might decide; while he would be watched by the delegates of the respective parties, having the power of interest stimulating them to attention; and would be sure that the merits or demerits of his conduct would be made fully known to the whole, or the greater part of the world.

Form of procedure before the International Tribunal.

The judicatory being thus constituted, the mode of proceeding before it may be easily sketched.

The cases may be divided into those brought before it by the parties concerned in the dispute; and those which it would be its duty to take up, when they were not brought before it by any of the parties.

A variety of cases would occur, in which two nations, having a ground of dispute, and being unable to agree, would unite in an application to the international tribunal for an adjustment of their differences. On such occasions, the course of the tribunal would be sufficiently clear. The parties would plead the grounds of their several claims; the judge would determine how far, according to the law, they were competent to support those claims; the parties would adduce their evidence for and against the facts, on which the determination of the claims was found to depend; the judge would receive that evidence, and finally decide. All this is so perfectly conformable to the course of pleading, and receiving proof, in the case of suits between individuals, as analyzed and explained in the Article JURISPRUDENCE, that it is unnecessary to be more particular here. If farther exposition is required, it will be found upon a reference to the article to which we allude. Decision, in this case, it is observable, fully accomplishes its end; because the parties come with an intention of obeying it.

Another, and a numerous class of cases, would probably be constituted, by those who would come before it, complaining of a violation of their rights by another nation, and calling for redress.

This set of cases is analogous to that, in private judicature, when one man prosecutes another for some punishable offence.

It should be incumbent upon the party thus applying to give notice of its intention to the party against which it is to complain, and of the day on

which it means that its complaint should be presented.

If both parties are present, when the case comes forward for trial, they both plead, according to the mode described in the Article JURISPRUDENCE; evidence is taken upon the decisive facts; and if injury has been committed, the amount of compensation is decreed. When it happens that the defendant is not present, and refuses to plead, or to submit, in this instance, to the jurisdiction of the court, the inquiry should notwithstanding go on; the allegations of the party present should be heard, and the evidence which it adduces should be received. The non-appearance of the party defendant should be treated as an article of evidence to prove the truth of its opponent's allegations. And the fact of not appearing should, itself, be treated as an offence against the law of nations.

It happens, not unfrequently, when nations quarrel, that both parties are in the wrong; and on some of these occasions neither party might think proper to apply to an equitable tribunal. This fact, namely, that of their not applying to the international tribunal, should, itself, as stated before, be marked in the code as an international offence, and should be denounced as such by the international tribunal. But even when two offending parties do not ask for a decision from the international tribunal, it is not proper that other nations should be deprived of the benefit of such a decision. If these decisions constitute a security against injustice from one another to the general community of nations, that security must not be allowed to be impaired by the refractory conduct of those who dread an investigation of their conduct.

Certain forms, not difficult to devise, should be laid down, according to which, on the occurrence of such cases, the tribunal should proceed. First of all, it is evident, that the parties in question should receive intimation of the intention of the court to take cognisance of their disputes, on a certain day. If the parties, one or both, appeared, the case would fall under one of those which have been previously as above considered. If neither party appeared, the court would proceed to estimate the facts which were within its cognisance.

It would have before it one important article of evidence, furnished by the parties themselves, namely, the fact of their non-appearance. This ought to be considered as going far to prove injurious conduct on both sides. The evidence which the court would have before it, to many specific facts, would be liable to be scanty, from the neglect of the parties to adduce their pleas and evidence. The business of the court, in these circumstances, would be, to state correctly such evidence, direct or circumstantial, as it had before it; giving its full weight to the evidence contained in the fact of non-appearance; and to pronounce the decision, which the balance of the evidence, such as it was, might be found to support.

Even in this case, in which the practical effect of a decision of the international court may be supposed to be the least, where neither party is disposed to respect the jurisdiction, the benefit which would be derived would by no means be inconsiderable. A decision solemnly pronounced by such a tribunal, would always have a strong effect upon the imaginations of men. It would fix, and concentrate the disapprobation of mankind.

Such a tribunal would operate as a great school of political morality. By sifting the circumstances, in all the disputes of nations, by distinguishing accurately between the false colours and the true, by stripping off all disguises, by getting at the real facts, and exhibiting them in the true point of view, by presenting all this to the world, and fixing the attention of mankind upon it by all the celebrity of its elevated situation, it would teach men at large to distinguish. By habit of contemplating the approbation of such a court attached to just proceeding, its disapprobation to unjust; men would learn to apply correctly their own approbation, and disapprobation; whence would flow the various important effects, which these sentiments, justly excited, would naturally and unavoidably produce.

As, for the reasons adduced at the beginning of this article, the intention should never be entertained of supporting the decisions of the international court by force of arms, it remains to be considered what means of another kind could be had recourse to, in order to raise to as high a pitch as possible the motive of nations respectively to yield obedience to its decisions.

We have already spoken of the effect which would be produced, in pointing the sentiments of mankind, giving strength to the moral sanction, and by the existence of an accurate code, and by the decisions themselves of a well constituted tribunal.

To increase this effect to the utmost, publicity should be carried to the highest practicable perfection. The code, of course, ought to be universally promulgated and known. Not only that, but the best means should be in full operation for diffusing a knowledge of the proceedings of the tribunal; of the cases investigated, the allegations made, the evidence adduced, the sentence pronounced, and the reasons upon which it is grounded.

The book of the law of nations, and selections from the book of the trials before the international tribunal, should form a subject of study in every school, and a knowledge of them a necessary part of every man's education. In this manner a moral sentiment would grow up, which would, in time, act as a powerful restraining force upon the injustice of nations, and give a wonderful efficacy to the international jurisdiction. No nation would like to be the object of the contempt and hatred of all other nations; to be spoken of by them on all occasions with disgust and indignation. On the other hand, there is no nation, which does not value highly the favourable sentiments of other nations; which is not elevated and delighted with the knowledge that its justice, generosity, and magnanimity, are the theme of general applause. When means are taken to make it certain that what affords a nation this high satisfaction will follow a just and beneficial course of conduct; that what it regards with so much aversion, will infallibly happen to it, if it fails in the propriety of its own behaviour, we may be sure that a strong security is gained for a good intercourse among nations.

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Besides this, it does not seem impossible to find various inconveniencies, to which, by way of penalties, those nations might be subjected, which refused to conform to the prescriptions of the international code.

Various privileges granted to other nations, in their intercourse with one another, might be withheld from that nation which thus demeaned itself in a way so contrary to the general interests. In so far as the withholding of these privileges might operate unfavourably upon individuals belonging to the refractory nations,—individuals who might be little, or not at all, accessary to the guilt, the effect would be the subject of proportional regret. Many, however, in the concerns of mankind, are the good things which can only be attained with a certain accompaniment of evil. The rule of wisdom, in such cases, is, to be sure that the good outweighs the evil, and to reduce the evil to its narrowest dimensions.

We may take an instance first from trivial matters. The ceremonial of other nations might be turned against the nation, which, in this common concern, set itself in opposition to the interests of others. The lowest place in company, the least respectful situation on all occasions of ceremony, might be assigned to the members of that nation, when travelling or residing in other countries. Many of those marks of disrespect, implying neither injury to person nor property, which are checked by penalties in respect to others, might be free from penalties in respect to them. From these instances, adduced merely to illustrate our meaning, it will be easy to see in what manner a number of considerable inconveniencies might, from this source, be made to bear upon nations refusing to conform to the beneficial provisions of the international code.

Besides the ceremonial of other nations, means to the same end might be derived from the law. A number of cases might be found in which certain benefits of the law, granted to other foreigners, might be refused to them. They might be denied the privilege of suing in the courts, for example, on account of any thing except some of the higher crimes, the more serious violations of person or property.

Among other things it is sufficiently evident, that this tribunal would be the proper organ for the trial of piracy. When preponderant inconvenience might attend the removing of the trial to the usual seat of the tribunal, it might delegate for that purpose the proper functionaries to the proper spot.

By the application of the principles, which we have thus expounded, an application which implies no peculiar difficulty, and requires nothing more than care in the detail, we are satisfied that all might be done, which is capable of being done, toward securing the benefits of international law.

(F.F.)

NAVY.

An insular empire, like that of the United Kingdom of Great Britain and Ireland, which is so much indebted, and always must be, for that power, prosperity, and renown which she enjoys, to the glorious deeds of her Navy, cannot but take a peculiar degree of interest in every thing that concerns it. This vast machine, indeed, has at all times been the pride and boast of Great Britain, the terror of its enemies, and the admiration of the world. It is under the impression of its vast importance that we have been induced to give, under their proper heads, such details of the civil and military branches of the naval departments, as may afford, without entering into too minute details, a comprehensive sketch of this great national bulwark, of which it is now proposed to take a general view.

The term Navy is generally intended to express all ships of commerce as well as of war—the mercantile as well as the military marine; but the observations contained in the present article are meant to relate only to the latter, excepting that, in speaking of the progressive enlargement of ships, and improvements in naval architecture, the remarks may sometimes equally apply to ships of commerce and of war.

Navy composed of Materiel and Personel.

The composition of a navy may be considered under the two distinct heads into which it naturally divides itself, and under which the French generally distinguish an army, the *materiel,* and the *personel;* the former embracing every thing that appertains to the ships, their capacity, construction, armament, and equipment; the latter all that concerns the rank, the appointment, the various duties, &c. of the officers, seamen, and marines.

I.—Materiel of the Navy.

History.

It would occupy too large a space to give even a short sketch of the origin and progress of naval architecture, from a bundle of branches, or the hollow trunk of a tree—the rude raft and the frail canoe—to the more perfect coracle, or the wicker boats of the ancient Britons covered with hides. For many centuries after the expulsion of the Romans from, or their abandonment of, the British Islands, very little progress appears to have been made by us in the art of navigation or ship building: the natives would appear, for many centuries afterwards, to have acted merely on the defensive against naval invasions.

"The whole of our naval history," say the Commissioners for Revising the Civil Affairs of the Navy, "may be divided into three periods. The *First,* comprehending all that preceded the reign of Henry VIII. The *Second,* ending with the Restoration of Charles II.; and the *Third,* coming down from the Restoration to the present day."

First Period.

To what size, and to what extent, the amount of the English ships or vessels were carried, which sup-

ported so many contests with the invading Danes, in the ninth century, our naval history has not preserved any record. We are told, however, that Alfred increased the size of his gallies, and that some of them were capable of rowing thirty pair of oars. These gallies were chiefly employed in clearing the Channel of the nests of pirates by which it was infested. It is also said, as a proof of his attention to naval matters, that under his auspices, one Ochter undertook a voyage into the Arctic Regions, made a survey of the coasts of Lapland and Norway, and brought to Alfred an account of the mode pursued by the inhabitants of those countries to catch whales. It is, moreover, on record, that his two sons, Edward and Athelston, fought many bloody actions with the Danes, in which several kings and chiefs were slain; and that Edgar had from 3000 to 5000 ships, divided into three fleets, stationed on three several parts of the coast, with which, passing from one fleet or squadron to the other, he circumnavigated the island; that after this he called himself "Monarch of all Albion, and Sovereign over all the adjacent Isles." Some notion, however, may be formed of the size of the vessels which composed his fleets, from the imposition of a land-tax, which required certain proprietors to furnish a stout galley of three rows of oars to protect the coast from the Danish pirates. The more effectually to check these marauders, and protect the coasts of the kingdom, William the Conqueror, in 1066, established the Cinque Ports, and gave them certain privileges, on condition of their furnishing 52 ships with 24 men in each for 15 days, in cases of emergency. We should not, perhaps, be far amiss in dating the period of our naval architecture from the Conquest. "The Normans," says Sir Walter Ralegh, "grew better shipwrights than either the Danes or Saxons, and made the last conquest of this land; a land which can never be conquered whilst the kings thereof keep the dominion of the seas." But Ralegh does not describe what the ships were which the Normans taught us to build; nor can it now be known in what kind of vessels William transported his army across the Channel, or what was the description of the hundred large ships and fifty gallies of which the naval armament of Richard I. consisted on his expedition to the Holy Land. We are told, however, that having increased his fleet at Cyprus to 250 ships, and 60 gallies, he fell in with a ship belonging to the Saracens, of such an extraordinary size, that she was defended by 1500 men, all of whom, with the exception of 200, Richard, after taking possession of her, ordered to be thrown overboard and drowned.

There can be no doubt that the nations of the Mediterranean, particularly the Genoese and Venetians, introduced many improvements as to the capacity and stability of their ships, in consequence of the crusades and the demands for warlike stores and provisions, which such vast and ill-provided armies necessarily created; but these improvements would seem not to have reached, or, at least, to have made but a tardy progress in Great Britain. King John, it is true, stoutly claimed for England the sovereignty of the sea, and decreed that all ships belonging to foreign nations, the masters of which should refuse to strike to the British flag, should be seized and deemed good and lawful prize. And this monarch is said to have fitted out no less than 500 sail of ships, under the Earl of Salisbury, in the year 1213, against a fleet of three times that number, prepared by Philip of France, for the invasion of England; of which the English took 300 sail, and drove 100 on shore, Philip being under the necessity of destroying the remainder, to prevent their falling also into the hands of the English. Of the kinds of ships of which his fleet consisted, some notion may be formed by the account that is related of an action fought in the following reign with the French, who, with "80 stout ships," threatened the coast of Kent. This fleet being discovered by Hubert de Burgh, governor of Dover Castle, he put to sea with 40 English ships, and having got to the windward of the enemy, and run down many of the smaller ships, he closed with the rest, and threw on board them a quantity of quicklime, which blinded them so effectually, that all their ships were either taken or sunk.

Whatever the size and the armaments of our ships were, the empire of the sea was bravely maintained by the Edwards and the Henrys in many a gallant and glorious sea-fight with the fleets of France, against which they were generally opposed with inferior numbers. The temper of the times, and the public feeling, were strongly exemplified in the reign of Edward I. by the following circumstance: An English sailor was killed in a Norman port, in consequence of which a war commenced, and the two nations agreed to decide the dispute on a certain day, with the whole of their respective naval forces. The spot of battle was to be the middle of the Channel, marked out by anchoring there an empty ship. The two fleets met on the 14th April 1293; the English obtained the victory, and carried off above 250 sail.

In an action with the French fleet off the harbour of Sluys, Edward III. is said to have slain 30,000 of the enemy, to have taken 200 great ships, "in one of which, only, there were 400 dead bodies." This is no doubt an exaggeration. The same monarch, at the siege of Calais, is stated to have blockaded that port with 730 sail, having on board 14,956 mariners; 25 only of which were of the Royal navy, bearing 419 mariners, or about 17 men each. In various other sea actions did this great sovereign nobly support the honour of the British flag. But though we then, and ever after, claimed the "dominion of the seas," that dominion, says Ralegh, "was never absolute until the time of Henry the Eighth." It was a maxim of this great statesman, that "whosoever commands the sea, commands the trade of the world; whosoever commands the trade, commands the riches of the world, and consequently the world itself."

The reign of Henry V., however, was most glorious, in maintaining the naval superiority over the fleets of France. From a letter of this Sovereign to his Lord Chancellor, dated 12th August 1417, discovered by the late Mr Lysons among the records in the Tower, and of which the following is a copy, it would appear that there was something like an established

Royal navy in his reign, independently of the shipping furnished by the Cinque Ports and the merchants, for the King's own use, on occasion of any particular expedition. The letter appears to have been written nine days after the surrender of the castle of Touque in Normandy, from whence it is dated.

"*Au revénd pere en Dieu L'evesque de Duresme nre Chanceller D'Engleterre.*

"Worshipful fader yn God We sende you closed within this letter a cedule conteyning the names of certein Maistres for owr owne grete Shippes Carrakes Barges and Balyngers to the whiche Maistres We have granted annuitees such as is appointed upon eche of hem in the same Cedule to take yerely of owre grante while that us lust at owr Exchequer of Westmr. at the termes of Michelmasse and Ester by even porcions. Wherefore We wol and charge yow that unto eche of the said Maistres ye do make under owr grete seel beyng in yowre warde owr letters patentes severales in due forme after th'effect and pourport of owr said grante. Yeven under owr signet atte owr Castle of Touque the xij day of August."

Extract from the Schedule contained in the preceding Letter.

vj. li. xiijs. iiijd. La Grande Nief appelle the dont John William est Maistre	vj. Mariners por la sauf garde deink Hamult
vj. li. xiijs. iiijd. La Trinate Royale dont Steph' Thomas est Maistre	vj. Mariners
vj. li. xiijs. iiijd. La Holy gost dont Jordan Brownyng est Maistre	vj. Mariners
vj. li. xiijs. iiijd. La Carrake appellee le Petre dont John Gerard est Maistre	vj. Mariners
vj. li. xiijs. iiijd. La Carrake appellee le Paul dont William Payne est Maistre	vj. Mariners
vj. li. xiijs. iiijd. La Carrak appelle le Andrewe dont John Thornyng est Maistr'	vj. Mariners
vj. li. xiijs. iiijd. La Carrak appellee le Xpōfre dont Tendrell est Maistr'	vj. Mariners
vj. li. xiijs. iiijd. La Carrak appelle le Marie dont William Richeman est Maistr'	vj. Mariners
vj. li. xiijs. iiijd. La Carrak appellee le Marie dont William Hethe est Maistre	vj. Mariners
vj. li. xiijs. iiijd. La Carrak appelle le George dont John Mersh est Maistr'	vj. Mariners

The remainder, to whose masters pensions were thus granted, consist of seventeen "niefs, barges, and ballyngers," some with three, and others two mariners only. But history informs us, that about this time Henry embarked an army of 25,000 men at Dover on board of 1500 sail of ships, two of which carried purple sails, embroidered with the arms of England and France; one styled the King's Chamber, the other his Saloon, as typical of his keeping his court at sea, which he considered as a part of his dominions. Still we are left in the dark as to the real dimensions of his ships, and the nature of their armament; they were probably used only as transports for his army. It would appear, however, from a very curious poem, written in the early part of the reign of King Henry the Sixth, that the navy of his predecessor was considerable, but that, by neglect, it was then reduced to the same state in which it had been during the preceding reigns. The poem here alluded to is entitled, "The English policie, exhorting all England to keep the sea, and namely the Narrow Sea; showing what profit cometh thereof, and also what worship and salvation to England and to all Englishmen," and is printed in the first volume of Hackluyt's *Collection of Voyages*. It was evidently written before the year 1438, when the Emperor Sigismond died, as appears by the following passage in the prologue:

"For Sigismond, the great Emperour,
Which yet reigneth, when he was in this land,
With King Henry the Fifth, Prince of Honour,
Here much glory, as him thought, he found
A mightie land, which had take in hand
To werre with France, and make mortalitie,
And ever well kept round about the sea."

The part of the poem which alludes to the navy of King Henry the Fifth is entitled, "Another incident of keeping the Sea, in the time of marveilous werriour and victorious Prince, King Henrie the Fifth, and of his great Shippes."

The following are the most remarkable passages:

"And if I should conclude all by the King
Henrie the Fift, what was his purposing,
Whan at Hampton he made the great *dromons*,
Which passed other great ships of the Commons;
The *Trinitie*, the *Grace de Dieu*, the *Holy Ghost*,
And other moe, which as nowe be lost.
What hope ye was the Kings great intent
Of thoo shippes, and what in mind he meant:
It was not ellis, but that *he cast to bee*
Lorde round about environ of the see.
And if he had to this time lived here,
He had been Prince named withouten pere:
His great ships should have been put in preefe,
Unto the ende that he ment of in chiefe.
For doubt it not but that he would have bee
Lord and master about the round see:
And kept it sure, to stoppe our ennemies hence,
And wonne us good, and wisely brought it thence,
That no passage should be without danger,
And his licence on see to move and sterre."

Shortly after the time when this poem must have been written, it appears from the Parliament Roll (20th Hen. VI. 1442), that an armed naval force, consisting only of eight large ships, with smaller vessels to attend them, was to be collected from the ports of London, Bristol, Dartmouth, Hull and Newcastle, Winchelsea, Plymouth, Falmouth, &c.; and, of course, the Royal ships of 1417, the names or which are contained in the foregoing schedule, were then either gone to decay or dispersed. We are not to judge of the size of these ships from the few mariners appointed to each. These were merely the

Navy.

ship-keepers, or harbour-duty men, placed on permanent pay, to keep the ships in a condition fit for the sea when wanted.

Second Period.

It is very probable that, until our merchants engaged in the Mediterranean trade, and that the attention of the government was turned in the reign of Henry VII. (about 1496), to imitate Portugal in making foreign discovery, under the skilful seaman Sebastian Cabot, very little was added to the capacity or the power of British ships of war. It is said, however, that on the accession of Henry VII. to the throne in 1485, he caused his marine, which had been neglected in the preceding reign, to be put into a condition to protect the coasts against all foreign invasions; and that, in the midst of profound peace, he always kept up a fleet ready to act. In his reign was built a ship called the Great Harry, the first on record that deserved the name of a ship of war, if it was not the first exclusively appropriated to the service of the state. This is the same ship that Camden has miscalled the Henry Grace de Dieu, and which was not built till twenty years afterwards, under the reign of Henry VIII. The Great Harry is stated to have cost L. 14,000, and was burnt by accident at Woolwich in 1553.

We now come to that period of our naval history in which England might be truly said to possess a military marine, and of which some curious details have been left us by that extraordinary man of business Mr Pepys, a commissioner of the navy, and afterwards secretary to Charles II., at a time when the King executed in person the office of Lord High Admiral, and also to James II. until his abdication. His minutes and miscellanies relative to the navy are contained in a great number of manuscript volumes, which are deposited in the Pepysian Library in Magdalene College, Cambridge. From these papers it appears, that in the thirteenth year of Henry VIII., the following were the names and the tonnage of the Royal Navy:

	Tons.
Henry Grace de Dieu, - -	1500
Gabriel Royal, - - -	650
Mary Rose, - - -	600
Barbara, - - - -	400
Mary George, - - -	250
Henry Hampton, - - -	120
The Great Galley, - - -	800
Sovereign, - - -	800
Catherine Forteleza, - - -	550
John Baptist, - - -	400
Great Nicholas, - - -	400
Mary James, - - -	240
Great Bark, - - - -	250
Less Bark, - - -	180

Two row-barges of 60 tons each,—making, in the whole, 16 ships and vessels measuring 7260 tons.

The Henry Grace de Dieu is stated in all other accounts, and with more probability, to have been only 1000 tons; the rule for ascertaining the measurement of ships being still vague and liable to great error, was probably much more so at this early period. This ship was built in 1515 at Erith, in the river Thames, to replace the Regent of the same tonnage, which was burnt in August 1512, in action with the French fleet, when carrying the flag of the Lord High Admiral. There is a drawing in the Pepysian papers of the Henry Grace de Dieu, from which a print in the Archaeologia has been engraved, and of which a copy has been taken as a frontispiece to Mr Derrick's *Memoirs of the Rise and Progress of the Royal Navy*. From these papers it appears, that she carried 14 guns on the lower deck, 12 on the main deck, 18 on the quarter-deck and poop, 18 on the lofty forecastle, and 10 in her stern ports, making altogether 72 guns. Her regular establishment of men is said to have consisted of 349 soldiers, 301 mariners, and 50 gunners, making altogether 700 men. Some idea may be formed of the awkwardness in manœuvring ships built on her construction or similar to her, when it is stated that, on the appearance of the French fleet at St Helens, the Great Harry, built in the former reign, and the first ship built with two decks, had nearly been sunk, and that the Mary Rose of 600 tons, with 500 or 600 men on board, was actually sunk at Spithead, occasioned, as Ralegh says, "by a little sway in casting the ship about, her ports being within sixteen inches of the water." On this occasion the fleets cannonaded each other for two hours; and it is remarked as something extraordinary, that not less than 300 cannon-shot were fired on both sides in the course of this action. From the prints above mentioned, which agree very closely with the curious painting of Henry crossing the Channel in his fleet, to meet Francis on the "Champ de drap d'Or," near Calais, (and now in the great room where the Society of Antiquaries hold their meetings in Somerset House,) it is quite surprising how they could be trusted on the sea at all; their enormous poops and forecastles making them appear loftier and more awkward than the large Chinese junks, to which, indeed, they bear a strong resemblance.

Henry VIII. may justly be said to have laid the foundation of the British navy. He established the dock-yards at Deptford, Woolwich, and Portsmouth; he appointed certain commissioners to superintend the civil affairs of the navy, and settled the rank and pay of admirals, vice-admirals, and inferior officers; thus creating a national navy, and raising the officers to a separate and distinct profession. The great officers of the navy then were, the Vice-Admiral of England; the Master of the Ordnance; the Surveyor of the Marine Causes; the Treasurer, Comptroller, General Surveyor of the Victualling, Clerk of the Ships, and Clerk of the Stores. Each of these officers had their particular duties, but they met together at their office on Tower-Hill once a week, to consult, and make their reports to the Lord High Admiral. He also established the fraternity of the Trinity-House, for the improvement of navigation and the encouragement of commerce, and built the castles of Deal, Walmer, Sandgate, Hurst Castle, &c. for the protection of his fleet and of the coast.

At the death of Henry VIII. in 1547, the Royal navy consisted of about 50 ships and vessels of different sizes, the former from 1000 to 150 tons, and the latter down to 20 tons, making in the whole about 12,000 tons, and manned by about 8000 mariners,

soldiers, gunners, &c. In the short reign of his son Edward, little alteration seems to have taken place in the state and condition of the Royal navy. But the regulations which had been made in the reign of his father, for the civil government of naval affairs, were revised, arranged, and turned into ordinances, which form the basis of all the subsequent instructions given to the commissioners for the management of the civil affairs of the navy. In the reign of Mary the tonnage of the navy was reduced to about 7000 tons; but her Lord High Admiral nobly maintained the title assumed by England of "Sovereign of the Seas," by compelling Philip of Spain to strike his flag that was flying at the main-top-mast head, though on his way to England to marry Queen Mary, by firing a shot at the Spanish admiral. He also demanded that his whole fleet, consisting of 160 sail, should strike their colours and lower their top-sails, as an homage to the English flag, before he would permit his squadron to salute the Spanish monarch.

The reign of Elizabeth was the proudest period of our naval history, perhaps surpassed by none, previous to the Revolution. She not only increased the numerical force of the regular navy, but established many wise regulations for its preservation, and for securing adequate supplies of timber and other naval stores. She placed her naval officers on a more respectable footing, and encouraged foreign trade and geographical discoveries, so that she acquired justly the title of the "Restorer of Naval Power, and Sovereign of the Northern Seas." The greatest naval force that had at any previous period been called together was that which was assembled to oppose the "Invincible Armada," and which consisted, according to the notes of Mr Secretary Pepys, of 176 ships, with 14,992 men; but these were not all "Shippes Royall," but were partly composed of the contributions of the Cinque Ports and others. The number actually belonging to the navy is variously stated, but they would appear to have been somewhere about 40 sail of ships, manned with about 6000 men. At the end of her reign, however, the navy had greatly increased, the list in 1603 consisting of 42 ships of various descriptions, amounting to 17,000 tons, and manned with 8346 men. Of these two were of the burden of 1000 tons each, three of 900 tons, and ten from 600 to 800 tons.

James I. was not inattentive to his navy. He warmly patronized Mr Phineas Pett, the most able and scientific shipwright that this country ever boasted, and to whom we undoubtedly owe the first essential improvements in the form and construction of ships. The cumbrous top-works were first got rid of under his superintendence. "In my owne time," says Ralegh, "the shape of our English ships hath been greatly bettered—in extremity we carry our ordnance better than we were wont—we have added crosse pillars in our royall shippes, to strengthen them; we have given longer floors to our shippes than in older times," &c. The young Prince Henry was so fond of naval affairs, that Phineas Pett was ordered, by the Lord High Admiral, to build a vessel at Chatham in 1604 with all possible speed, for the young Prince Henry to disport himself in, above London Bridge; the length of her keel was 28 feet, and her breadth 12 feet. In 1610 Pett laid down the largest ship that had hitherto been built. She was named the Prince Royal; her burden 1400 tons; her keel 114 feet; and armed with 64 pieces of great ordnance; "being in all respects," says Stowe, "the greatest and goodliest ship that was ever built in England." He adds, "the great workmaster in building this ship was Mr Phineas Pett, gentleman, sometime Master of Arts, of Emanuel College, in Cambridge."

This excellent man, as appears from a manuscript account of his life in the British Museum, written by himself, was regarded by the shipwrights of the dock-yards, who had no science themselves, with an eye of jealousy, and a complaint was laid against him before the King, of ignorance in laying off a ship, and of a wasteful expenditure of timber and other matters. The King attended at Woolwich with his court, to inquire in person into the charges brought forward, and, after a painful investigation, pronounced in favour of Mr Pett. One of the charges was, that he had caused the wood to be cut across the grain; but the King observed, that, as it appeared to him, "it was not the wood, but those who had preferred the charges, that were cross-grained."

The state of the navy at the King's death is variously given, by different writers, but on this subject the memoranda left by Mr Secretary Pepys are most likely to be correct. From them it appears, that, in 1618, certain commissioners were appointed to examine into the state of the navy; and, by their report, it appears there were then only 39 ships and vessels, whose tonnage amounted to 14,700 tons; but in 1624, on the same authority, the numbers had decreased to 32 or 33 ships and vessels, but the tonnage increased to about 19,400 tons. The commissioners had, in fact, recommended many of the small craft to be broken up or sold, and more ships of the higher rates to be kept up.

The navy was not neglected in the troublesome reign of Charles I. This unfortunate monarch added upwards of 20 sail to the list, generally of the smaller kind; but one of them, built by Pett, of a description, both as to form and dimensions, far superior to any that had yet been launched. This ship was the celebrated "Sovereign of the Seas," which was launched at Woolwich in 1637. The length of her keel was 128 feet, and main breadth 48 feet, and from stem to stern 232 feet. In the description of this ship by Thomas Heywood, she is said to have "bore five lanthorns, the biggest of which would hold ten persons upright; had three flush-decks, a forecastle, half-deck, quarter-deck, and round-house. Her lower tier had 30 ports for cannon and demi-cannon; middle tier, 30 for culverines and demi-culverines; third tier, 26 for other ordnance; forecastle, 12; and two half-decks, 13 or 14 ports more within board, for murthering pieces; besides 10 pieces of chace ordnance, forward, and 10 right aft, and many loop-holes in the cabins for musquet-shot. She had 11 anchors, one of 4400 pounds weight. She was of the burthen of 1637 tons." It appears, however, that she was found, on

trial, to be too high for a good serviceable ship in all weathers, and was, therefore, cut down to a deck less. After this she became an excellent ship, was in almost all the great actions with the Dutch; was rebuilt in 1684, and the name changed to that of "Royal Sovereign;" was about to be rebuilt a second time at Chatham in 1696, when she accidentally took fire, and was totally consumed. In this reign the ships of the navy were first classed, or divided into six rates; the first being from 100 to 60 guns; the second from 54 to 36, &c.

In 1642 the management of the navy was taken out of the King's hands, and in 1648 Prince Rupert carried away 25 ships, none of which ever returned; and such, indeed, was the reduced state of the navy, that at the beginning of Cromwell's usurped government, he had only 14 ships of war of two decks, and some of these carried only 40 guns; but under the careful management of very able men, in different commissions which he appointed, such vigorous measures were pursued, that, in five years, though engaged within that time in war with the greatest naval power in Europe, the fleet was increased to 150 sail, of which more than a third part had two decks; and many of which were captured from the Dutch; and upwards of 20,000 seamen were employed in the navy. Our military marine was, indeed, raised by Cromwell to a height which it had never before reached; but from which it soon declined under the short and feeble administration of his son.

Though Cromwell found the navy divided into six rates or classes, it was under his government that these ratings were defined and established in the manner nearly in which they now are; and it may also be remarked, that, under his government, the first frigate, called the Constant Warwick, was built in England. "She was built," says Mr Pepys, "in 1649, by Mr Peter Pett (son of Phineas), for a privateer for the Earl of Warwick, and was sold by him to the state. Mr Pett took his model of this ship from a French frigate, which he had seen in the Thames."

During the first period of our naval history, we know nothing of the nature of the armament of the ships. From the time of Edward III. they might have been armed with cannon, but no mention is made of this being the case. According to Lord Herbert, brass ordnance were first cast in England in the year 1535. They had various names, such as cannon, demi-cannon, culverins, demi-culverins, sakers, mynions, falcons, falconets, &c. What the calibre of each of these were is not accurately known, but the cannon is supposed to have been about 60 pounders, the demi-cannon 32, the culverin 18, falcon 2, mynion 4, saker 5, &c. Many of these pieces, of different calibres, were mounted on the same deck, which must have occasioned great confusion in action in finding for each its proper shot.

Third Period.

On the Restoration of Charles II. the Duke of York was immediately appointed Lord High Admiral; and by his advice, a committee was named to consider a plan, proposed by himself, for the future regulation of the affairs of the navy, at which the Duke himself presided. By the advice and able assistance of Mr Pepys, great progress was speedily made in the reparation and increase of the fleet. The Duke remained Lord High Admiral till 1673, when, in consequence of the test required by Parliament, to which he could not submit, he resigned, and that office was in part put in commission, and the rest retained by the King. Prince Rupert was put at the head of this commission, and Mr Pepys appointed secretary to the King in all naval affairs, and of the admiralty; and by his able and judicious management, there were in sea-pay, in the year 1679, and in excellent condition, 76 ships of the line, all furnished with stores for six months, eight fire-ships, besides a numerous train of ketches, smacks, yachts, &c. with more than 12,000 seamen; and also 30 new ships building, and a good supply of stores in the dock-yards. But this flourishing condition of the navy did not last long. In consequence of the dissipation of the King, and his pecuniary difficulties, he neglected the navy on account of the expences; the Duke was sent abroad, and Mr Pepys to the Tower. A new set of commissioners were appointed, without experience, ability, or industry; and the consequence was, as stated by the commissioners of revision, that "all the wise regulations, formed during the administration of the Duke of York, were neglected; and such supineness and waste appear to have prevailed, that, at the end of not more than five years, when he was recalled to the office of Lord High Admiral, only 22 ships, none larger than a fourth rate, with two fire-ships, were at sea; those in harbour were quite unfit for service; even the 30 new ships which he had left building had been suffered to fall into a state of great decay, and hardly any stores were found to remain in the dock-yards."

The first act on the Duke's return was the re-appointment of Mr Pepys as secretary of the admiralty. Finding the present commissioners unequal to the duties required of them, he recommended others. Sir Anthony Dean, the most experienced of the shipbuilders then in England, was joined with the new commissioners. To him, it has been said, we owe the first essential improvement in the form and qualities of ships of the line, having taken the model of the Superbe, a French ship of 74 guns, which anchored at Spithead, and from which he built the Harwich in 1664. Others, however, are of opinion that no improvement had at this time been made on the model of the Sovereign of the Seas after she was cut down. The new commissioners undertook, in three years, to complete the repair of the fleet, and furnish the dock-yards with a proper supply of stores, on an estimate of L. 400,000 a year, to be issued in weekly payments; and in two years and a half they finished their task, to the satisfaction of the King and the whole nation; the number of ships repaired and under repair being 108 sail of the line, besides a considerable number of vessels of smaller size. The same year the King abdicated the throne, at which time the list of the navy amounted to 173 sail, containing 101,892 tons, carrying 6930 guns, and 42,000 seamen.

The naval regulations were wisely left unaltered at the Revolution, and the business of the Admiralty continued to be carried on chiefly, for some time,

under the immediate direction of King William, by Mr Pepys, till the arrival of Admiral Herbert and Captain Russell from the fleet, into whose hands, he says, "he silently let it fall." Upon the general principles of that system, thus established with his aid by the Duke of York, the civil government of our navy has ever since been carried on.

In the second year of King William (1690), no less than 30 ships were ordered to be built, of 60, 70, and 80 guns each; and in 1697, the King, in his speech to Parliament, stated that the naval force of the kingdom was increased to nearly double what he found it at his accession. It was now partly composed of various classes of French ships which had been captured in the course of the war, amounting in number to more than 60, and in guns to 2300; the losses by storms and captures on our side being about half the tonnage and half the guns we had acquired. At the commencement of this reign, the navy, as we have stated, consisted of 173 ships, measuring 101,892 tons; at his death, it had been extended to 272 ships, measuring 159,020 tons, being an increase of 99 ships and 57,128 tons, or more than one-half both in number and in tonnage.

The accession of Queen Anne was immediately followed by a war with France and Spain, and in the second year of her reign, she had the misfortune of losing a vast number of her ships by one of the most tremendous storms that was ever known; but every energy was used to repair this national calamity. In an address to the House of Lords in March 1707, it is declared as "a most undoubted maxim, that the honour, security, and wealth of this kingdom does depend upon the protection and encouragement of trade, and the improving and right encouraging its naval strength .... therefore, we do in the most earnest manner beseech your Majesty, that the sea-affairs may always be your first and most peculiar care." In the course of this war were taken or destroyed about 50 ships of war, mounting 3000 cannon; and we lost about half the number. At the death of the Queen in 1714, the list of the navy was reduced in number to 247 ships, measuring 167,219 tons, being an increase in tonnage of 8199 tons.

George I. left the navy pretty nearly in the same state he found it. At his death, in 1727, the list consisted of 233 ships, measuring 170,862 tons, being a decrease in number of 14, but an increase in tonnage of 3643 tons.

George II. was engaged in a war with Spain in 1739, in consequence of which the size of our ships of the line ordered to be built was considerably increased. In 1744, France declared against us; but on the restoration of peace in 1748, it was found that our naval strength had prodigiously increased. Our loss had been little or nothing, whilst we had taken and destroyed, of the French 20, and of the Spanish 15 sail of the line, besides smaller vessels. The war with France of 1755 added considerably to the list, so that, at the King's decease, in 1760, it consisted of 412 ships, measuring 321,104 tons.

In the short war of 1762, George III. added no less than 20 sail of the line to our navy. At the conclusion of the American war in 1782, the list of the navy was increased to 600 sail; and at the signing of the preliminaries in 1783, it amounted to 617 sail, measuring upwards of 500,000 tons; being an increase of 185 ships and 157,000 tons and upwards since the year 1762. At the peace of Amiens, the list of the fleet amounted to upwards of 700 sail, of which 144 were of the line. The number taken from the enemy, or destroyed, amounted nearly to 600, of which 90 were of the line, including 50 gun ships, and upwards of 200 were frigates; and our loss amounted to about 60, of which 6 were of the line and 12 frigates.

The recommencement and long continuance of the Revolutionary war, and the glorious successes of our naval actions, the protection required for our extended commerce, of which, in fact, we might be said to enjoy a monopoly, and for the security of our numerous colonies, contributed to raise the British navy to a magnitude to which the accumulated navies of the whole world bore but a small proportion. From 1808 to 1813, there were seldom less than from 100 to 106 sail of the line in commission, and from 130 to 160 frigates, and upwards of 200 sloops, besides bombs, gun-brigs, cutters, schooners, &c., amounting in the whole to about 500 sail of effective ships and vessels; to which may be added 500 more in the ordinary, and as prison, hospital, and receiving ships; making at least 1000 pendents, and measuring from 800,000 to 900,000 tons. The commissioners appointed to inquire into the state and condition of the woods, forests, and land revenues of the Crown, state, in their report to Parliament, in the year 1792, that, "at the accession of his Majesty (Geo. III.) to the throne, the tonnage of the Royal navy was 321,104 tons, and at the end of the year 1788, it had risen to no less than 413,467 tons." In 1808 it had amounted to the enormous extent of 800,000 tons, having nearly doubled itself in twenty years.

It must not, however, be supposed that the effective navy consisted of more than half this amount of tonnage. Since the conclusion of the war, it would appear that at least one-half of the number of ships then in existence have been sold or broken up as unfit for the service; and as, by the list of the navy at the beginning of the year 1821, the number of ships and vessels of every description in commission, in ordinary, building, repairing, and ordered to be built, has been reduced to 609 sail, we may take the greatest extent of the present tonnage at 500,000 tons; but the greatest part, if not the whole, of this tonnage may be considered as efficient, or in a state of progressive efficiency.

According to the printed list of the 1st January 1821, the 609 sail of ships and vessels appear to be as under:

					No.
1st Rates	from	120	to	100 guns,	23
2d Rates	——	86	—	80 do.	16
3d Rates	——	78	—	74 do.	90
4th Rates	——	60	—	50 do.	20
5th Rates	——	48	—	22 do.	107
6th Rates	——	34	—	24 do.	40
Sloops	——	22	—	10 do.	136
				Making a total of	432

Navy.

Brought forward, -	432
To which being added gun-brigs, cutters, schooners, tenders, bombs, troop-ships, store-ships, yachts, &c. - -	177
Grand total,	609

The increase in the size of our ships of war was unavoidable; France and Spain increased theirs, and we were compelled, in order to meet them on fair terms, to increase the dimensions of ours; many of theirs were, besides, added to the list of our navy. The following sketch will show the progressive rate at which ships of the first rate, or of 100 guns and upwards, were enlarged in their dimensions. In 1677 the first rates were from 1500 to 1600 tons. In 1720 they were increased to 1800 tons. In 1745 we find them advanced to 2000 tons. During the American war they were raised to 2000 tons. In 1795 the Ville de Paris, of 110 guns, measured 2350 tons. In 1804 the Hibernia, of 110 guns, was extended to 2500 tons; and in 1808 the Caledonia, carrying 120 guns, measured 2616 tons, and here we stopped; but since then, the Nelson, the Howe, the St Vincent, the Britannia, the Prince Regent, the Royal George, and the Neptune, have been built, or building, all nearly of the same dimensions, and from the same draught—nine such ships as the whole world beside cannot produce. The French had one ship larger than any of these, called the Commerce de Marseilles. She was taken by us in Toulon, but broke her back in a gale of wind.

The following are the comparative dimensions of the Caledonia and the Commerce de Marseilles:

	Length of Gun-deck.		Length of Keel.		Extreme Breadth.		Depth of Hold.		Tons.
	feet.	in.	feet.	in.	feet.	in.	feet.	in.	
Commerce de Marseilles,	205	0	170	9	53	8	23	2	2616
Caledonia, - -	208	4	172	0	54	9½	25	0½	2747

The following is the armament of the Caledonia: On the gun-deck she carries 32 guns, 32-pounders; middle-deck 34 24-pounders; upper deck 34 24-pounders, carronades; quarter-deck 10 32-pounders, and 6 12-pounders, carronades; forecastle 2 32-pounders, and 2 12-pounders, carronades. Her complement of men 875.

At the commencement of the *third period*, we have a somewhat more precise account of the armament of our ships of war. On the 16th May 1677, a Committee of the Navy Board, Ordnance, and certain naval officers, recommended to his Majesty the following scheme for arming and manning the 30 new ships of the line ordered to be built by act of Parliament.

Guns.	1st Rates.	2d Rates.	3d Rates.
Cannon (supposed 42 prs.).	No. 26		
Demi-cannon (32 prs.),		26	26
Culverins (18 prs.),	28	26	
Twelve pounders,			26
Sakers, upper-deck,	28	26	
Forecastle,	4		4
Quarter-deck,	12	10	10
Three pounders,	2	2	4
	100	90	70

For the 1st rate, 780 men.
For the 2d do. 660 do.
For the 3d do. 470 do.

The rates of ships immediately after the Revolution were reduced, the 1st being turned to 2d rates, 2d rates to 3d, &c., and the size of each class more equalized. But from this time forward it was found impossible to preserve any thing like uniformity in the several classes. So many ships captured from the French, Dutch, and Spaniards, were added to our navy, and so many new ones built after the models of ships taken from these maritime powers, that the various descriptions of ships of which our navy was composed became a very serious evil.

In the year 1745, a committee, composed of all flag officers unemployed, of the commissioners of the navy, who were sea-officers, under the presidency of Sir John Norris, and assisted by the master shipwrights, were ordered to meet, to consider, and propose proper establishments of guns, men, masts, yards, &c. for each class of his Majesty's ships; and, according to their recommendation, the rates, armaments, and complements of his Majesty's ships were to be as follows:

Rate.	Guns.	Men.
1	100	850 or 750
2	90	750 or 660
3	80	650 or 600
	70	520 or 460
4	60	420 or 380
	50	350 or 280
5	44	280 or 220
6	24	160 or 140

But this establishment was very soon departed from; for, on the 3d of February 1747, the Board of Admiralty acquainted his Majesty, that the French ship Invincible, lately captured, was found to be larger than his Majesty's ships of 90 guns, and 750 men; and suggested that this ship, and all other prizes of the like class, and also his Majesty's ships of 90 guns, when reduced to two decks and a half, and 74 guns, should be allowed a complement of 700 men. And it further appears, that, at the latter end of the reign of George the Second, the rates of ships had undergone a very material alteration, for they consisted as under:

1st Rate, 100 guns.
2d Rate, 90 guns.

3d Rate,	80 guns,	74—70—64 guns.
4th Rate,	60 guns,	50
5th Rate,	44 guns,	38—36—32 guns.
6th Rate,	30 guns,	28—24—20 guns.

The scales for measuring the ships were as various as their rates; and the evil was further increased by the varieties, which it was found necessary to introduce in the rigging and arming the ships of war. The masts, yards, rigging, and stores, were of so many and various dimensions, as to be not only highly inconvenient, but extremely expensive. When Lord Nelson was off Cadiz with 17 or 18 sail of the line, he had no less than *seven* different classes of 74 gun ships, each requiring different sized masts, sails, yards, &c. so that, in the event of one of these being disabled, the others could not supply her with such stores as could be appropriated to her wants.

Present Rating of the Navy.

To remedy the many inconveniences resulting from the irregularities above mentioned, the Lords of the Admiralty suggested, by their Memorial to the Prince Regent, which, by his Order in Council, of the 25th November 1816, was ordered to be carried into effect, that the ships of the navy should for the future be rated as under:

The 1st rate to include all three-deckers, in as much as all sea going ships of that description carry 100 guns and upwards.

The 2d rate to include all ships of 80 guns and upwards, on two decks.

The 3d rate to include all ships of 70 guns and upwards, and less than 80 guns.

The 4th rate to include all ships of 50 and upwards, but less than 70 guns.

The 5th rate to include all ships from 36 to 50 guns.

The 6th rate to include all ships from 24 to 36 guns.

And that the complements of men be established as under:

1st Rate,	900 — 850 or 800 men
2d do.	700 or 650
3d do.	650 or 600
4th do.	450 or 350
5th do.	300 or 280
6th do.	175 — 145 or 125.

Of sloops the complements established according to their size, to consist of 135, 125, 95, or 75 men. Brigs (not sloops), cutters, schooners, and bombs, with 60 or 50 men.

Thus stands the rating and manning of the navy at present; but another war, or a new administration of the affairs of the navy, will, in all human probability, make new regulations in these respects. It is, however, of the utmost importance, with a view to convenience and economy, that the size and dimensions of the several rates should be kept as nearly as possible equal, in order that one description of stores may be applicable to every ship of the same rate. To this end, the commissioners of naval revision have recommended, "that the ships of each class or rate should be constructed in every particular, according to the form of the best ship in the same class in our navy; of the same length, breadth, and depth; the masts of the same dimensions, and placed in the same parts of the ship, with the same form and size of the sails."

Improvements in Construction.

If we look back to the days of Elizabeth, when the chain-pump, the capstan, the striking of the top-masts, the studding sails, top-gallant-sails, sprit-sails, &c. were first introduced into the navy, one can scarcely conceive how they contrived to keep the sea for any length of time; but these improvements, important as they were, are trifling when compared with those aids and conveniences which have gradually been introduced since her reign, and which a ship of war now enjoys. When Sir Anthony Deane, in 1664, raised the lower ports of a two-decker four and a half feet out of the water, which had before been scarcely three feet, and made a ship of this class to stow six months' provisions instead of three, it was justly considered as a most important improvement; not less so, when the breadth of a ship of this class was carried to 45 feet. "The builders of England," says Pepys, "before 1673, had not well considered that breadth only will make a stiff ship." It must be confessed, however, that as far as the form of a ship's bottom depends on scientific principles, we have copied our best models from the French, sometimes with capricious variations, which more frequently turned out to be an injurious alteration than an improvement.

The first essential alteration in the form of our ships of the line was taken from the *Superbe*, a French ship of 74 guns, which anchored at Spithead, on the model of which, as already stated, the Harwich was built by Sir Anthony Deane in 1674; since which time we have constantly been copying from French models; improving or spoiling, as chance might determine. "Where we have built exactly after the form of the best of the French ships that we have taken," say the commissioners of naval revision, "thus adding our dexterity in building to their knowledge in theory, the ships, it is generally allowed, have proved the best in our navy; but whenever our builders have been so far misled by their little attainments in the science of naval architecture, as to depart from the model before them in any material degree, and attempt improvements, the true principles on which ships ought to be constructed (being imperfectly known to them) have been mistaken or counteracted, and the alterations, according to the information given to us, have, in many cases, done harm:" while, therefore, they add, "our rivals in naval power were employing men of the greatest talents and most extensive acquirements, to call in the aid of science for improving the construction of ships, we have contented ourselves with groping on in the dark, in quest of such discoveries as chance might bring in our way."

On these grounds, and by the recommendation of the commissioners, a school for a superior class of shipwright apprentices has been established in Portsmouth Dockyard. It consists of twenty-five young men of liberal education; whose mornings are passed in the study of mathematics and mechanics, and in their

application to naval architecture; and the remainder of the day under the master shipwright in the mould loft, and in all the various kinds of manual labour connected with ship-building, as well as in the management and conversion of timber, so as to make them, at the same time, fully acquainted with all the duties in detail of a practical shipwright.

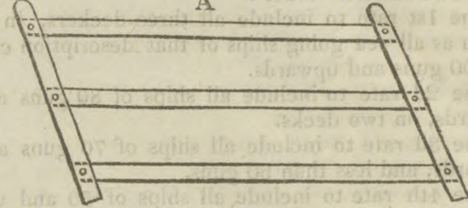
If, however, we have hitherto been inferior to the French in the scientific principles of ship-building, in the constructive part we have left them behind beyond all comparison; and notwithstanding the narrow prejudices which have been more remarkably adhered to among shipwrights, than among almost any other class of artisans, various alterations and improvements have from time to time been introduced into the mechanical part of naval architecture, which have added to the strength, the stability, the comfort, and convenience of our ships of war, and rendered them, in every point of view, superior to those of any other nation. The application of iron where wood was formerly used, and of copper for iron, have added considerably to the durability of ships; and the sheathing their bottoms with copper, to their celerity; giving them, at the same time, a protection against the worm and those marine insects which were wont to adhere to them; yet, it is remarkable, how strong the prejudice was against this practice before it obtained a due degree of credit. In the fleet of Sir Edward Hughes in India there was but one coppered ship, and Rodney's squadron in the West Indies had but four that were coppered in the year 1779; but these were enough so completely to establish their superiority over the others with wooden sheathing, that, in the year 1782, the whole British navy was coppered.

System of Diagonal Bracing.

But the greatest of all improvements in the construction of ships of war, as tending to their strength and durability, is the system of diagonal bracing, introduced a few years ago by Mr (now Sir Robert) Seppings, surveyor of the navy, and now universally adopted in all ships of the line and frigates; a system that may be said to have established a new era in naval architecture. Of all large machines destined to undergo severe shocks, a ship is perhaps the least skilfully and artificially contrived. Her several parts are put together on a principle so much opposed to that which constitutes strength, that if a ship, on the old construction, should be put upon wheels, and drawn over a rough pavement, the action of a day would shake her in pieces; but being destined to move in an element that closes upon her, and presses her equally on all sides, she is prevented from falling in pieces outwards, and her beams and decks preserve her from tumbling inwards. Whoever has observed a ship *in frame*, as it is called, on the stocks, that is, with only her timbers erected, must forcibly be reminded of the skeleton of some large quadruped, as of a horse or ox, laid on its back; the keel resembling the back-bone, and the curved timbers the ribs, which is, in fact, the name by which they sometimes go. These ribs, issuing at right angles from the keel, consist, in a 74 gun-ship, of about 800 different pieces, the space between each rib seldom exceeding five inches. These ribs are covered with a skin or planks of different thickness within and without, also at right angles to the ribs, and fixed to them by means of wooden pins or tree-nails. In the inside three or four tier of beams cross the skeleton from side to side, at right angles to both planks and ribs. These beams support the decks. At right angles to the beams are pieces of wood called carlings, and at right angles to these other pieces called ledges, and upon these the planks of the deck are laid in a direction of right angles to the beams, and parallel to the planking of the sides. From this sketch it will be perceived, that all the parts of a ship are either parallel or at right angles to each other. The ribs form a right angle with the keel, the planks inside and out are at right angles to the ribs, the beams at right angles to these, the carlings to the beams, the ledges to the carlings, and the planks of the decks to the ledges, the beams, and the ribs.

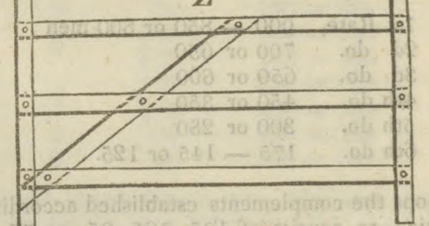
Now, it is well known to every common carpenter that this disposition of materials is the weakest that can be adopted. Thus, if five pieces of wood be pinned together in the shape of a parallelogram, it will require but little force to move them from the rectangular to the oblique or rhomboidal shape, as

A



But place a cross-bar, as in the figure Z, as carpenters are accustomed to do on a common gate, and it is no longer moveable on the points of fastening.

Z



The strongest proof of a ship's partaking of this weakness in the old construction, is afforded on her being first launched into the water, when it is invariably found that the two extremities, being less water-borne than the middle, drop, and give to the ship a convex curvature upwards, an effect which, from its resemblance to the shape of a hog's back, is usually called *hogging*. In very weak or old ships this effect may be discovered in all the port-holes of the upper-deck, by their having taken the shape of lozenges declining different ways from the centre of the ship to each extremity.

To obviate this great defect, Seppings tried the experiment of applying to the ribs or timbers of the ship, from one extremity to the other, and from the orlop-deck downwards to the kelson, that well-known principle in carpentry, called *trussing;* being, in fact, a series of diagonal braces disposing themselves into triangles, the sides of which give to each other a mutual support and counteraction. These triangles were firmly bolted to the frame; and in order to give a continuity of strength to the whole machine, and leave no possible room for play, he filled the spaces between the frames with old seasoned timber cut into the shape of wedges; but recently with a prepared cement, thus rendering the lower part of the ship or floor one solid complete mass, possessing the strength and firmness of a rock.

The same principle of trussing is carried from the gun-deck upwards, from whence, between every port, is introduced a diagonal brace, which completely prevents the tendency of ships to stretch, or draw asunder their upper works. The decks, too, are made subservient to the securing more firmly the beams to the sides of the ship, by the planks being laid diagonally in contrary directions, from the midships to the sides, and at an angle of 45° with the beams, and at right angles with the ledges.

In frigates and smaller vessels, iron plates, lying at an angle of 45° with the direction of the trusses, are substituted for the diagonal frame of wood in ships of the line.

By this mode of construction, the ceiling, or internal planking, is wholly dispensed with, and a very considerable saving of the finest oak timber thereby effected; and what is more important, those receptacles of filth and vermin between the timbers, which were before closed up by the planking, entirely got rid of. This is not the least important part of the improvement, either as it concerns the soundness of the ship, or the health of the crew. It is stated, that a ship, which had been three years in India, on being laid open, exhibited a mass of filth, mixed up with dead rats, mice, cockroaches, and other vermin, which was taken out in cakes, not unlike in appearance the oil-cake with which certain animals are fed; that the stench was abominable, and the timbers with which it was in contact rotten. No such filth can find a lodgment in ships of war as they are now built.

The first ships on which the new principle was tried were those rebuilt or repaired in docks, from which they were quietly floated out without any shock from launching; but several of them sustained severe gales of wind, without showing the least symptoms of weakness, but quite the contrary, not even a crack appearing in the white-wash with which their sides within were covered. If these experiments were not satisfactory, the launching of two of the largest ships in the navy, established the fact of superior strength beyond the possibility of a doubt—the Nelson and the Howe. The Nelson, constructed on the old principle, was probably, in every respect, the best built ship in modern times; the timber sound and well seasoned; the workmanship admirable; and no pains were left unemployed by Mr Sison, the builder, to have her as perfect as she could be made; and her motion, when launched from the stocks, was slow, easy, and majestic, without a shake or a plunge; yet the Nelson was found to have arched, after launching, no less than 9½ inches. The Howe is a sister ship to the Nelson, but built on the new principle; and after launching, she was found to have arched only three inches and five-eighths. The St Vincent, built on the old principle, and the same in every respect as the Howe, likewise hogged on launching nine inches and a quarter; and the whole fabric, in both cases, was found, on examination, to be greatly disturbed; whereas the Howe exhibited no such symptoms. The Plate No. CI. will show the mode of trussing ships of the line according to the plans of Sir Robert Seppings, now universally adopted in the British navy.

Fastenings.

It has been a subject of discussion among ship-builders, whether tree-nails or metallic fastenings are to be preferred. The objection to iron bolts is, their rapid corrosion from the gallic acid of the wood, the sea-water, and perhaps by a combination of both; in consequence of which, the fibres of the wood around them become injured, the bolts wear away, the water oozes through, and the whole fabric is shaken and deranged. This corrosion of iron fastenings was most remarkable when the practice of sheathing ships with copper became general, and when iron nails were made use of to fix it: by the contact of the two metals and the sea-water, both were immediately corroded. Mixed metal nails are now used for this purpose; and copper bolts are universally employed below the line of flotation, though it is found that in these also oxidation takes place to a certain degree, and causes partial leaks. Various mixtures of metals have been tried, but all of them are considered to be liable to greater objections than pure copper. It would appear, then, that tree-nails, if properly made, well seasoned, and driven tight, are the least objectionable, being seldom found to occasion leaks, or to injure the plank or timbers through which they pass. This species of fastening has at all times been used by all the maritime nations of Europe. The Dutch were in the habit of importing them from Ireland, it being supposed that the oak grown in that country was more tough and strong than any which could be procured on the Continent, and in all respects best adapted for the purpose. "Under all circumstances," says Mr Knowles, "it appears that the present method of fastening ships generally with tough well seasoned tree-nails, with their ends split, and caulked after being driven, and securing the buts of each plank with copper bolts well clenched, is liable to fewer objections, and more conducive to the durability of the timber, than any other which has been tried, or proposed to be established."

Round Bows to Ships of the Line.

The rounding the form of the bow, in ships of the line, is considered, by nautical men, of great utility and importance. The plan was first proposed by Seppings in 1807, and has since been generally adopted. The removal of the head railing, and the continuing of the rounded form, give not only great additional strength to the ship, but also much more comfort and convenience to the crew, and security in that part of the ship when in action.

Scarphing a Substitute for Compass Timber.

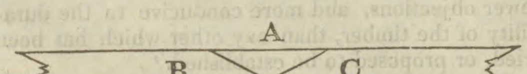
The scarcity of compass or crooked timber was, for some time, attended with serious injury to those ships of war, while on the stocks, into which it was considered necessary to be introduced. The difficulty with which it was procured, the length of time which a ship sometimes remained on the stocks waiting for a few pieces of compass timber, the green wood, when found, being immediately added to the seasoned timber in other parts of the frame, gave to the ship different periods of durability; though, in the long-run, the seasoned parts became affected by the green wood with which they were in contact, and a premature decay of the whole fabric was the consequence. Seppings, therefore, proposed a plan in 1806, which, by uniting short timbers according to a method called *scarphing*, enabled him to obtain every species of compass-form that could be required from straight timber. Since that period, the whole frame of a ship can be prepared at once, without waiting for particular pieces, and thus every part of it be made to undergo an equal degree of seasoning.

Plan for rendering Frigate Timber applicable to Ships of the Line.

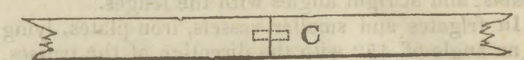
By the same ingenious and indefatigable surveyor of the navy, a plan was proposed and adopted in the year 1813, by which ships of the line were built with timber hitherto considered as applicable only to the building of frigates, and that which had been deemed only fit for inferior uses was appropriated to principal purposes. The Talavera was the first ship built on this principle, and the expence of her hull is stated to have been about a thousand pounds less than that of the Black Prince, a ship of similar dimensions built on the old principle. The method by which the timbers were united was found, on trial of the Talavera with the Black Prince, while in frame, to give so much additional strength to the former, that it furnished the ground-work of the present mode of framing the British navy, by the introduction of the same union of materials in the application of the large, as was practised in that of the small timber; and from which both strength and economy have been united.

Use of Chocks abolished.

The building of the Talavera, and the great strength of her frame, led to the practice of putting together the frames of ships of the line from timbers of reduced lengths, and dispensing altogether with the chocks used for uniting their extremities, or, as they are technically called, their heads and heels. These chocks are of the form of an obtuse wedge, as A, and they are used to unite the two pieces of timber, as B and C, by firmly bolting the piece A to the two timbers B and C.



It generally happened, however, that, in the operation of thus fixing this chock, its two extremities split, and the surfaces of the chock and timbers not being in perfect contact, the moisture and air were admitted, and occasioned, as they always do, the dry-rot to a greater degree in those parts of the ship than in most others; and as there were from four to five hundred of these chocks in a 74 gun-ship, it will readily be conceived what mischief was done to the whole fabric, if the greatest care was not taken by the workmen to prevent their splitting, and to bring their surfaces immediately into contact. It is obvious, also, that a great deal of timber must have been cut to waste in making these chocks; and, in fact, they consumed timber in each ship, when it was at a high price, to the value of from L.1500 to L.2000, besides a considerable expence in workmanship; and when the ship came to be repaired, not one chock in six was found to be in a fit state to be used again. It is not easy to conceive how this practice of uniting the timbers of a ship's frame came to be introduced so generally into the British navy, more especially as it is unknown in any other nation; it was probably first done to preserve the length of some particular timbers, one of whose ends might be defective, and the unsound part cut away in the manner we see it, and the sound chock introduced to fill up the vacuity; but it is quite surprising how a practice should have become general which creates a waste of timber, an increase of workmanship, and sows the seeds of premature decay. To obviate these disadvantages, Sir Robert Seppings brought the butt ends of the timbers together thus,



and kept them together by means of a round dowal or coak, as C, just as the fellies of a carriage wheel are fastened together. He justly observes, that the simplicity of the workmanship, the economy in the conversion of timber, and the greater strength and durability, although of considerable moment, are of trifling importance when compared with the advantage of rendering timber generally more applicable to the frames of ships, which had heretofore been but partially so.

Another great improvement in the construction of ships of war, introduced by Seppings, is the round stern, which, however unsightly it may at first appear, from being accustomed to view the square stern with its grotesque carved work, is even in appearance more consistent with the termination of the sweeping lines of a ship's bottom, than the cutting them off abruptly with a square stern. But the additional strength which is thus given to a ship in that part which was hitherto the weakest, is alone sufficient to recommend the adoption of the plan, in our ships of war, particularly in those of the larger classes. The advantages gained by circular sterns are thus enumerated by Sir Robert Seppings.

1. They give additional strength to the whole fabric of a ship.
2. They afford additional force in point of defence.
3. They admit of the guns being run out in a similar way to those in the sides.
4. From the circular form and mode of carrying up the timbers, an additional protection against shot is obtained, if the ship should be raked.
5. The stern being equally strong as the bow, no serious injury can accrue in the event of the ship being pooped; and the ship may be moored, if so required, by the stern.

6. A ship will sail better upon a wind, from the removal of the projections of the quarter galleries.

7. Ships of the line have now a stern-walk protected by a veranda, and so contrived that the officers can walk all round, can observe the set of the sails, and the fleet in all directions.

8. The compass-timber heretofore expended for transoms is substituted with straight timber, and worked nearly to a right angle, which affords a considerable saving in the consumption of timber.

9. The counter being done away by the circular stern, the danger which arose from boats being caught under it is obviated.

In fact, the circular stern possesses many other advantages not necessary to be enumerated in this place.

Improvements in the Preservation of the Navy.

Not only the new mode of construction is highly favourable to the duration of ships, but the ravages of the disease known by the name of the dry-rot, occasioned principally by the hurry in which ships were built in the course of the late war, and the unseasoned state of the timber made use of (see DRY-ROT), led to such measures as tend most effectually to the preservation of the fleet.

By Prevention of Dry-Rot.

In the first place, various modes were put in practice for assorting and seasoning the timber, and for protecting it from the vicissitudes of the weather. The oak and fir of Canada, which had been introduced to a great extent into our dock-yards, during the time the Baltic was shut against this country, are now excluded; these woods having been found not only to possess little durability, but so friendly to the growth of fungi, that they communicated the baneful disease to all other descriptions of timber with which they came in contact. The practice of building ships under cover, introduced into our dock-yards in the course of the war, and carried to an extent so as to have roofed over almost every dock and slip in all the yards, has been destructive to the growth of dry-rot. (See DOCK-YARDS.) By filling in between the timbers masses of cement, and then injecting by forcing-pumps a mixture of oil and tar, into all the joints and crevices of the frames; and lastly, by the care and very constant attention bestowed on ships after leaving the dock-yard, and being placed in a state of ordinary, it may be said that the dry-rot has no longer any existence in the British navy.

By Precautions in Ordinary.

A ship now placed in ordinary, whether new or newly repaired, is carefully housed over, so that no rain can reach her lower decks; several streaks of planks are removed from her sides and decks to admit a thorough draft of air, which is sent down by wind-sails, and which pervades every part of the ship, and these, with the addition of two small airing-stoves in which a few cinders are burned, render her perfectly dry and comfortable on all the decks and store-rooms. All the shingle ballast is removed out of the hold, which is thoroughly cleaned and restowed with iron ballast. The lower tier of iron tanks filled with pure fresh water serves to complete the ballast, and prevent her from hogging or arching. The former practice of mooring two ships together, by which the two sides next to each other, deprived of the sun and a free circulation of air, were generally found to be decayed, is discontinued. The lower masts are left standing, and their tops housed over; the gun-carriages and several of the stores are left on board; and such, in short, is the state of a ship in ordinary, that she may be fitted in all respects for proceeding to sea in half the usual time. "The ships," says Mr Knowles, "are frequently pumped to clear them of bilge-water; and cleanliness in every respect is attended to; the lower decks are rubbed with dry stones, commonly called holly-stones, and with sand, the use of water upon them being strictly forbidden." But that which most of all is likely to ensure the preservation of the fleet, while in a state of ordinary, is the recent regulation, which places the ordinary under the superintendence of a post-captain at each port, with several commissioned-officers under his orders, who take care that the warrant-officers and ship-keepers attend to the proper airing, ventilating, and keeping clean and dry their respective ships.

By Immersion of Timber in Salt-Water.

A practice has recently been introduced into the dock-yards, of steeping oak timber in salt-water for several months, and then stacking it till it becomes perfectly dry, which is said to have entirely put a stop to the progress of dry-rot, where it had already commenced, and to act as a preventive to that disease. We have heard some doubts entertained on this point. The Americans seem to place little confidence in the good effects which are said to have been experienced from the immersion of timber. Rodgers, the commissioner of their navy, states, in an official report addressed to the Secretary, that "experiments have been made to arrest the dry-rot in ships, by sinking them for months in salt-water, but without success. The texture of the wood was found to be essentially injured by being thus water soaked, and it became more subject to this disease than before it was sunk. The ships were also injured in their fastenings, and the atmosphere within them was kept in a constant state of humidity, whence, among other ill effects, proceeded injury to provisions and stores, and sickness to the crews." Now, we know that not one of these injurious effects happened to the Eden, which was sunk in Hamoaze, remained under water three or four months, was sent to India, and has been at sea ever since; but, from being covered with fungus before the operation, she has not showed a single symptom to dry-rot since the time of her being weighed, and continues a good sound ship. The truth is, the American timber, with the single exception, perhaps, of the live-oak, is remarkably subject to dry-rot, of which, during the late war, we had fatal experience. Mr Rodgers, however, accounts for the condition in which the oak and pine was received in England from Canada, by its immersion in water: "The Canada timber," he observes, "is brought down the St Lawrence in large rafts, continues months in water, and in that saturated state is landed and exposed to frost; every attempt to season it under cover is unavailing; its pores never close again, and when used as ship-timber, dry-rot ensues, which, when once commenced, can never be arrested, but by taking out all the pieces in any degree affected." The Russians, he says, are

Navy.

so fully aware of the injurious effects of soaking ship-timber in water, that it is brought from great distances down the rivers in crafts, instead of rafts. The Russian ships, however, with all this precaution, are not remarkable for durability. The ships built at Antwerp by the French were in a state of rottenness before they were launched; but whether this was owing to the bad quality of the timber of the German forests, or to its being water-soaked in rafting down the Rhine, remains doubtful. But we can have no doubt that porous timber is injured by moisture, though the solid British oak may be improved by the dissolution of its sap juices, to the fermentation of which the disease, known by the name of dry-rot, may chiefly be owing. "Water," says Lescalier, a French writer of considerable merit on the subject, "seems to be favourable to the decomposition of the sap of timber when immersed; but it substitutes in its place another kind of moisture not less destructive, of which the timber, though afterwards exposed to the air, will not easily get rid of; besides, it weakens and destroys the grain of the wood."—"The best means," he adds, "of preserving timber, appears to be that of keeping it in well constructed and airy sheds, in a vertical position, so that the moisture which remains in the interior of the logs, by running along the fibres of the wood, may be enabled to issue from the lower extremity. Timber thus kept dry, under shelter, will preserve itself for ages." Mr Knowles, secretary to the Committee of Surveyors of his Majesty's Navy, in his *Treatise on the Means of Preserving the British Navy*, is led to conclude, from a variety of experiments, "that timber is better seasoned when kept for two years and a half under cover, than when placed for six months in water, and then for two years in the air, protected from the rain and sun; that it loses more in seasoning, by having been, during the six months of immersion, alternately wet and dry, than the whole time under water; and that the loss in moisture is greater in all cases in a given time, when the butt-ends are placed downwards." And he adds as a general principle, "that no timber should be brought into use in this country, until it has been felled at least three years."

By Roofing the Ships.

Next to the system of diagonal braces, and making the bottoms of ships one compact and solid mass, the roofing, thrown over them while building, and in ordinary, may be considered as the greatest of all improvements for the preservation of the navy; the utility of which is so obvious, that it is quite extraordinary such a practice should not have been earlier adopted; more especially, as at Venice, at Carlscrona, and at Cronstadt, ships of war had long been built, repaired, and protected under covered roofs. It was strongly recommended to the English ship-builders fifty years ago, but without effect; and had it not been for the extraordinary ravages of the dry-rot in the unseasoned timber-built ships of the navy, we should still have been without roofs to our docks and slips.

By other Means.

If the dock-yards were of sufficient capacity, there can be no doubt that the efficient plan to accomplish their durability, would be that of keeping them on the slip, when built, under cover. It was stated by Mr Strange, when examined by the Commissioners for Land Revenue, that in the year 1790 there were 22 ships of the line under roofs, in the port of Venice, some of which had remained in that situation 59 years. Since, however, it is utterly impracticable to keep our navy on slips, or in dry docks, the next important consideration is, how best to preserve them afloat in a state of ordinary. Various expedients have been at different times resorted to in order to prevent the premature decay of ships laid up in this state during peace. The two great requisites for their preservation are ventilation and cleanliness. To promote the former, wind-sails were in general use, though, if not attended to so as to oppose the open part to the quarter from whence the wind blows, or if the weather be calm, they are of little benefit. Pneumatic machines of various kinds, as pumps and bellows, have been applied to force out the foul air, and introduce atmospherical air into the lower parts of a ship's hold. Heated air from stoves, placed in various parts of the ship, and conducted through tubes, was thought at one time to be efficacious in the preservation of the navy; but experience soon showed that the heat thus circulated was so far objectionable, as it tended to encourage the growth of fungus, where there was any moisture lodged, and in the timber which had not been thoroughly seasoned. Perhaps no better means can be suggested than those we have described to be in practice, namely, to keep them clean, to admit as much dry air as possible, and to exclude all moisture.

Finally, if we take into consideration the numerous improvements which a war, unparalleled in its duration, has been the means of introducing into the materiel of the navy, whether it regards the economy of its application, the construction of the ships, and their mode of preservation, we may safely say, that at no former period was this country in possession of such a navy as at present, in respect of the numbers, size, and good condition of the ships which compose a fleet, superior to those of the whole world besides; and it is gratifying to find, that, with all the enormous consumption of the military and mercantile navy, it does not appear that the naval resources of Great Britain are at all impaired.

Naval Resources.

It is of essential importance that the supply of stores for the use of the fleet should not only be adequate to the demand, but that a sufficient stock should be kept on hand to answer any sudden emergency. This is the more necessary with regard to those species of stores which are derived from foreign nations.

Principal Naval Stores.

The principal articles of consumption required for building and equipping a fleet are hemp, canvas, pitch, tar, iron, copper, and timber. All these articles might unquestionably be produced in sufficient quantities in the United Kingdom and her colonies, if necessity absolutely required it. Hemp, for instance, might be grown to any extent in Great Britain and Ireland, were not the land more advantageously employed in raising other articles of consumption; and if it could not be cheaper imported from Russia. In the East Indies, the Sunn hemp

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(inferior it is true to Russia hemp) might be procured to any extent, and other plants, both there and at home, might be substituted for the making of cordage and canvas. For pitch and tar, recourse might be had to the pitch lake on the island of Trinidad, and the coal tar, of which an inexhaustible supply may be had at home. The lake is about four miles in circumference, and many feet in depth of solid pitch; and it is stated that, when mixed with oil or tallow, it is rendered fit for all the purposes to which pitch and tar are usually applied. It has the advantage of securing ships' bottoms against the attack of the worm, which is very active in the neighbouring Gulf of Para; and it does not corrode iron. The coal tar of home manufacture, from some prejudice or other, was refused a fair trial till very lately; and it is now deemed not inferior for many purposes to the common tar. For painting or tarring over wood work of every kind, it is said to stand exposure to the weather even better than the common tar; and it is used for injecting in large quantities between the timbers of ships, as a preservative from the dry-rot; its powerful smell having also the good effect of driving rats and other vermin out of the ships on which it is employed.

Pitch and Tar.

Copper and Iron.

In the two important articles of copper and iron, our own resources may be considered inexhaustible. Formerly it was deemed indispensable that certain articles should be made of Swedish iron, but of late years our own has been manufactured in every respect equally good; and the extensive application of this metal in bridges, barges, dock-gates, roofs, rafters, floors, &c. has been equally progressive in most naval purposes. Iron knees and other modes of binding the beams to the side timbers of ships, are now substituted for those large and crooked pieces of timber which were once deemed absolutely necessary. Our cables, rigging, buoys, and tanks for holding water, are now of iron; and we understand that hollow masts of iron are actually constructing as an experiment, which, if successful, will do away the necessity of depending for a foreign supply of that most expensive and not very plentiful article, mast-timber.

Timber.

But the most important article of demand for the use of the navy is timber, principally oak; concerning the supply of which from our own territories, different opinions have been entertained. A deficiency in other articles may readily be supplied. A failure in the importation of hemp, for instance, in any one year, might be remedied the next, by an extended cultivation of that article; but it requires a whole century to repair any defalcation of oak timber, and to render us independent of other nations. Nor has the subject been sufficiently elucidated, so as to form a just opinion, by the several Committees of the House of Commons; the evidence produced being almost always loose, and generally contradictory. The committee of 1771, which was directed to inquire into the state of oak timber throughout the kingdom, either from a disagreement of opinion, or defect of evidence, or a wish to avoid giving alarm, prayed the House to discharge that part of its order which required them to report their opinion. The Commissioners of Woods and Forests, however, in their report laid before Parliament in 1792, appeared to establish the fact of an alarming scarcity of oak timber in general, but more particularly of large naval timber, both in the royal forests, and on private estates. And if such was really the fact in 1792, it will readily be conceived what the state of timber fit for naval purposes must have been at the conclusion of the Revolutionary war, when the amount of private shipping had increased from 1,300,000 tons to 2,500,000 tons, or nearly doubled; that of the East India Company, in the same period, from 79,900 tons to 115,000 tons; and that of the navy, from 400,000 to 800,000 tons, to say nothing of the vast consumption of oak timber in all kinds of mill-work and other machinery, in the barrack and ordnance departments—in mines, collieries, and agriculture—in docks, and dock-gates—in piers, locks, and sluices—in boats, barges, lighters, bridges, and a great many other purposes to which this timber is applied. From these, and many other causes, the diminution of oak timber was infinitely greater than the commissioners had calculated upon, and yet they recommended that 100,000 acres, belonging to the crown, should be set apart and planted, as necessary for the future supply of the navy. A bill to this effect, relating to the New Forest, passed the Commons, but was thrown out by the Lords.

Report of the Commissioners of Land-Revenue respecting Timber.

On the departments of the Surveyor-general of the Land Revenue, and the Surveyor-general of the Woods and Forests being united, the Board of Commissioners made their first report, which was printed, by order of the House of Commons, in June 1812. In this report, it is stated, that, taking the tonnage of the navy in 1806 at 776,087 tons, it would require, at $1\frac{1}{2}$ load to a ton, 1,164,085 loads to build such a navy; and supposing the average duration of a ship to be fourteen years, the annual quantity of timber required would be 83,149 loads, exclusive of repairs, which they calculate would be about 27,000 loads, making in the whole about 110,000 loads; of which, however, the commissioners reckon may be furnished 21,341 loads as the annual average of prizes: and of the remaining 88,659 loads, they think it not unreasonable to calculate on 28,659 from other sources than British oak. "This," they observe, "leaves 60,000 loads of such oak as the quantity which would be sufficient annually to support, at its present unexampled magnitude, the whole British navy, including ships of war of all sorts, but which may be taken as equivalent together to twenty 74 gun ships, each of which, one with another, contains about 2000 tons, or would require, at the rate of a load and a half to the ton, 3000 loads, making just 60,000 loads for twenty such ships."

Quantity of Timber required for the Navy.

Now, it has been supposed, that not more than 40 oak trees can stand on an acre of ground, so as to grow to a full size, fit for ships of the line, or to contain each a load and a half of timber; 50 acres, therefore, would be required to produce a sufficient quantity of timber to build a 74 gun ship, and 1000 acres for 20 such ships; and, as the oak requires at least 100 years to arrive at maturity, 100,000 acres would be required to keep up a successive supply, for maintaining a navy of seven or eight hundred thousand tons. The commissioners further observe,

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that as there are twenty millions of acres of waste lands in the kingdom, a two-hundredth part set aside for planting would at once furnish the whole quantity wanted for the use of the navy.

This calculation, we suspect, is overrated by about one-half. In the first place, it supposes a state of perpetual war, during which the tonnage of the whole navy is considered as more than double of what it now actually is; and, in the second place, it reckons the average duration of the navy at fourteen years only, which, from the improvements that have taken place in the construction and preservation of ships of war, with the resources of teak ships, built in India, we should not hesitate in assuming at an average of twice that number of years; and, if so, the quantity of oak required for the navy will be nothing like that which the commissioners have stated. This, we think, will appear from a statement made (apparently on good authority) in the midst of the war, when the ships of the line, built in merchants' yards, were falling to decay, after a service of five or six years.

"Assuming 400,000 tons as the amount of tonnage to be kept in commission, and the average duration of a ship of war at the moderate period of $12\frac{1}{2}$ years, there would be required an annual supply of tonnage, to preserve the navy in its present effective state, of 32,000 tons: and, as a load and a half of timber is employed for every ton, the annual demand will be 48,000 loads. The building of a 74 gun ship consumes about 2000 oak trees, or 3000 loads of timber, so that 48,000 loads will build 8 sail of the line and 16 frigates. Allowing one-fourth part more for casualties, the annual consumption will be about 60,000 loads, or 40,000 full-grown trees; of which 35 will stand upon an acre of ground. The quantity of timber, therefore, necessary for the construction of a 74 gun ship will occupy 57 acres of land, and the annual demand will be the produce of 1140 acres. Allowing only 90 years for the oak to arrive at perfection, there ought to be now standing 102,600 acres of oak plantations, and an annual felling and planting, in perpetual rotation, of 1140 acres to meet the consumption of the navy alone: large as this may seem, it is little more than 21 acres for each county in England and Wales; which is not equal to the belt which surrounds the park and pleasure grounds of many estates."

The above calculation proceeds on the principle that every acre is covered with trees fit for naval purposes, or that it contains 35 trees, with a load and a half of timber in each. It may be doubted, however, if, on the average of plantations, we shall find more than one-tenth of that number on an acre; and as the same writer endeavours to show, that the quantity of oak timber consumed in the navy is only about one-tenth part of the whole consumption of the country, instead of 120,600 acres being sufficient for a perpetual supply, there would be required some ten or twelve millions of acres, in plantations similar to those at present existing, to supply the demand for oak timber. Whether such a quantity exists or not, the fact is certain, that, long before the conclusion of the war, a scarcity began to be felt, especially of the larger kind of timber fit for ships of the line; and so great was this scarcity, that if Sir Robert Seppings had not contrived the means of substituting straight timber for those of a certain form and dimensions, before considered to be indispensable, the building of new ships must entirely have ceased.

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If, however, the growth of oak for ship timber was greatly diminished during the war, so as to threaten an alarming scarcity, there is little doubt, that, from the increased attention paid by individuals to their young plantations, and the great extension of those plantations, as well as from the measure of allotting off portions of the royal forests to those who had claims on them, and enclosing the remainder for the use of the public, this country will, in future times, be fully adequate to the production of oak timber equal to the demand for the naval and mercantile marine. It will require, however, large and successive plantations, on account of the slow growth of the oak. But there is another tree, of late years very generally planted on rising grounds, which bids fair to become an object of great national importance, as furnishing the best, and perhaps only substitute for oak timber. We mean the larch, which thrives well and grows rapidly in bad soils and exposed situations, the timber of which has been found to be durable, and from several experiments, not inferior in strength, toughness, and elasticity to oak. So rapid is its growth, that the Duke of Atholl received twelve guineas for a single larch fifty years old; the timber was valued at two shillings a foot. A larch of 70 years' growth produces timber fit for all naval purposes, and may be considered equal in size to an oak of double that age. The dimensions of a larch tree cut down at Blair Atholl in 1817, and then 79 years of age, were as follows: stem 82 feet; top 20 feet; total height 102 feet; girth at the ground 12 feet; at 19 feet, 8 feet $3\frac{1}{2}$ inches, and at 57 feet, 4 feet 10 inches; solid contents, 252,8 cubic feet. Another larch, now growing at Dunkeld, measured, in 1819, then 80 years old, and in full vigour, as follows: height of stem 75 feet, top 14 feet; total height 90 feet. At one foot from the ground, 17 feet 8 inches in girth; at 10 feet, 10 feet 4 inches, and at 70 feet, 3 feet 2 inches; its contents 300 cubic feet, or six loads. For all kinds of mill-work, as wheels, axle-trees, &c. the utility of the large larch wood is unquestionable; and the thinnings are excellent for pailing, rails, and hurdles. The value of its application for naval purposes is now under trial; two frigates of 28 guns, one built entirely of larch, from the Duke of Atholl's plantations, the other of Riga fir (which is inferior only to oak), being intended to go through the same service, precisely in the same parts of the world, in order to ascertain their comparative durability.

Indian Teak.

In addition to our resources of naval timber at home, we have wisely availed ourselves of those which India affords for building ships of war at Bombay of teak, a wood far superior in every respect to oak, and many times more durable; not liable to corrode iron or other metallic fastenings, not susceptible of the dry-rot, nor subject to the attack of the worm.

II.—Personel of the Navy.

The *personel* of the navy is composed of two different bodies of men—the Seamen and the Marines; each of whom have their appropriate officers.

Commissioned Officers.

The commissioned officers of the former consist of flag-officers, post-captains, commanders, and lieutenants. Flag-officers are divided into three ranks, and each rank into three squadrons, distinguished by the colours, red, white, and blue; as admiral of the red, white, or blue; vice-admiral of the red, white, or blue; rear-admiral of the red, white, or blue; the admiral wearing his colour at the main, the vice-admiral at the fore, and the rear-admiral at the mizen-mast-head. There is also an admiral of the fleet, who, if in command, would carry the union flag at the main. There are besides superannuated rear-admirals, enjoying the rank and pay of a rear-admiral, but incapable of rising to a higher rank on the list. There is also in the navy the temporary rank of commodore, who is generally an old post-captain, and is distinguished by wearing a broad pendant. He ranks next to the junior rear-admiral, and above all post-captains, except where the captain of the fleet shall be a post-captain, who, in that situation, takes rank next to the junior rear-admiral.

The commissioned officers of the navy take rank with those of the army, as follows:

Navy.	Army.
Admiral of the fleet,	Field-marshal.
Admiral,	General.
Vice-admiral,	Lieutenant-general.
Rear-admiral,	Major-general.
Commodore,	Brigadier-general.
Post-captain of 3 years,	Colonel.
Post-captain under ditto,	Lieutenant-colonel.
Commander,	Major.
Lieutenant,	Captain.

And all officers of the same rank command according to the priority of their commissions, or, having commissions of the same date, according to the order in which they stand on the list of the officers of the navy, except in the case of lieutenants of flag-ships, who take precedence according as the flag-officer shall think fit to appoint them.

Warrant Officers.

The warrant officers of the navy may be compared with the non-commissioned officers of the army. They take rank as follows: master, second master, gunner, boatswain, carpenter. There are other warrant officers of the navy, who, though non-combatants, constitute a part of the establishment of the larger classes of ships of war. These are, the chaplain, surgeon, surgeon's assistant, purser. To which may be added, as part of the staff of a fleet or squadron, secretary to the admiral or commander-in-chief, and physician of the fleet.

Petty Officers.

The petty officers are very numerous, the principal of whom are master's mates and midshipmen. Their names or ratings will be seen in the table of the establishment of the ratings and pay in the several classes of ships of war.

Order of Promotion.

By the King's Order in Council, the following regulations are established for the promotion of commissioned officers of the navy. Midshipmen are required to serve six years on board some of his Majesty's ships, two of which years they must have been rated as midshipmen, to render them eligible to the rank and situation of lieutenant; or, if educated at the Royal Naval College, four years service at sea qualify for a commission as lieutenant.

No lieutenant can be promoted to the rank of commander, until he has been on the list of lieutenants for two years; and no commander to the rank of post-captain until he has been on the list for one year. Post-captains become admirals in succession, according to their seniority on the list; but if a post-captain should not have served in the course of the preceding war, when his turn arrives he is passed over, and placed on the list of superannuated and retired captains; as are those captains likewise who have accepted of commissionerships or other civil employments, provided they retain those employments, when they come within the limits of a promotion to the rank of rear-admiral.

There is also a list of superannuated rear-admirals composed of those who, not having actually served at sea in the preceding war, have been employed in regulating new raised men, or in the sea fencibles, or who have made offers of service, although not accepted. They enjoy the rank and half pay of a rear-admiral, but can never be employed as such, or be promoted to a higher rank.

No person can be appointed to serve as master of one of his Majesty's ships, who shall not have served as second master; and no person can be appointed as second master, until he has passed such examination as may from time to time be directed.

No person can be appointed gunner or boatswain, unless he shall have served one year as a petty officer on board one or more of his Majesty's ships, and produce certificates of his good conduct, and undergo the necessary examination.

No person can be appointed carpenter, unless he shall have served an apprenticeship to a shipwright, and been six months a carpenter's mate on board one or more of his Majesty's ships.

No person can be appointed purser, unless he shall have been rated and discharged the duties of a captain's clerk for two complete years, one year as captain's clerk, and been employed in the office of the secretary to a flag-officer for one other year, produce good certificates, and find such security for the honest and faithful discharge of his duty as shall be required.

No person can be appointed chaplain to one of his Majesty's ships, until he has received Priest's orders; but may be appointed to act while in Deacon's orders.

No person can be appointed surgeon to one of his Majesty's ships, until, by long and meritorious services, he has discharged the duties of assistant surgeon; and all persons applying for the situation of assistant surgeon must undergo an examination touching their qualifications before the medical members of the victualling board.

Royal Marines.

The Royal Marines consist of four great divisions. 1st, Stationed at Chatham. 2d, At Portsmouth. 3d, At Plymouth. 4th, At Woolwich. They are com-

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posed of 72 companies, besides 8 companies of Royal Marine Artillery, whose head-quarters are at Fort Monckton, Gosport. The 1st division has 21 companies; the 2d, 18 companies; the 3d, 20 companies; and the 4th, 13 companies. The officers of Royal Marines take rank with officers of the line in the army.

A colonel commandant, who is a general officer in the corps, is resident in London; and to each of the divisions is a colonel commandant, two lieutenant-colonels, and two majors, with a proper number of captains and subaltern officers. While on shore the marines are subject to the same regulations as the army, but, when embarked, are liable to the naval articles of war.

The staff of the marine corps, consists of a general, a lieutenant-general, a major-general, who are all flag-officers of his Majesty's fleet; and four colonels, who are post-captains, near the head of the list, and are selected from those who may have distinguished themselves by their services.

The paymaster of marines is resident in London, but each division has its paymaster, a captain in the corps; a barrackmaster, also a captain; two adjutants, and a quartermaster, who are first lieutenants; and to each division is a surgeon, and an assistant-surgeon.

There is also a retired list of officers who, in consideration of wounds, infirmities, and long and meritorious services, are permitted to receive their full pay.

The commissions of officers, of every rank, in the marine corps, are signed by the King, but all commissions of officers of the navy are signed by two or more of the Lords Commissioners of the Admiralty. But the marines, whether ashore or afloat, are, as well as the officers of the navy, under the immediate direction and control of the Lords Commissioners of the Admiralty. All the appointments of commissioned and warrant officers to ships are made exclusively by the Lords of the Admiralty, or made subject to their confirmation, unless in cases of the death or dismissal of officers by sentence of Court-Martial on foreign stations, when the admiral commanding has the power to fill up the vacancies. And the duties of each rank are pointed out in a code of instructions emanating from that Board, and sanctioned by his Majesty's Order in Council.

Military Duties of the Lord High Admiral.

The civil powers and duties of the Lord High Admiral, or Lords Commissioners of the Admiralty, are treated of under the Article ADMIRAL in this *Supplement*. Their military powers are more extensive and important. By their orders, all ships are built, repaired, fitted for sea, or laid up in ordinary, broken up or sold; put in commission or out of commission, armed, stored, and provisioned; employed on the home or foreign stations. All appointments or removals of commission and warrant officers, with the exception of masters and surgeons, are made by them, and all instructions issued for the guidance of their commanders; all promotion in the several ranks emanate from them; all honours bestowed for brilliant services, and all pensions, gratuities, and superannuations for wounds, infirmities, and long services, are granted on their recommendation. All returns from the fleet are sent to the Board of Admiralty, and every thing that relates to the discipline and good order of every ship. All orders for the payment of naval monies are issued by the Lords Commissioners of the Admiralty, and the annual estimate of the expences of the navy prepared by them, and laid before Parliament for its sanction. All new inventions and experiments are tried by their orders before introduced into the service; all draughts of ships must be approved by them; all repairs, alterations, and improvements in the dock-yards, all new buildings of every description must be submitted for their decision before they are undertaken. But the Commissioners of the Navy are held responsible for keeping up a proper supply of naval stores of every kind, and the Victualling Board of provisions.

Commander-in-Chief.

All flag-officers, commanders-in-chief, are considered as responsible for the conduct of the fleet or squadron under their command; to keep them in perfect condition for service; to exercise them frequently in forming orders of sailing and lines of battle, and in performing all such evolutions as may occur in the presence of an enemy; to direct the commanders of squadrons and divisions; to inspect into the state of each ship under their command, to see that the established rules for good order, discipline, and cleanliness, be observed, and occasionally to inquire into these and other matters themselves. They are to correspond with the Secretary of the Admiralty, and report to him all their proceedings for the information of the Board.

If a commander-in-chief should be killed in battle, his flag is to be continued flying; intelligence to be conveyed by signal, or otherwise, to the next in command, who is immediately to repair on board, leaving his own flag (if a flag-officer) flying, and direct the operations of the fleet until the battle be ended, or the enemy out of sight.

Other Flag-Officers.

Every flag-officer serving in a fleet, but not commanding it, is to superintend all the ships of the squadron or division placed under his orders; to see that their crews are properly disciplined; that all orders are punctually attended to; that the stores, provisions, and water, are kept as complete as circumstances will admit; that the seamen and marines are frequently exercised; and that every precaution is taken for preserving the health of their crews; for all which he is responsible to the commander-in-chief. When at sea, he is to take care that every ship in his division preserve her station, in whatever line or order of sailing the fleet may be formed; and in battle, he is to observe attentively the conduct of every ship near him, whether of the squadron or division under his immediate command or not; and at the end of the battle, he is to report it to the commander-in-chief, in order that commendation or censure may be passed as the case may appear to merit; and he is empowered to send an officer to supersede any captain who may misbehave in battle, or whose ship is evidently avoiding the engagement. If any flag-officer be killed in battle, his flag is to be kept flying, and signals to be repeated, in the same manner as if he were still alive, until the battle shall be ended; but the death of a flag-

Navy. officer, or his being rendered incapable of attending to his duty, is to be conveyed as expeditiously as possible to the commander-in-chief.

Captain of the Fleet. The captain of the fleet is a temporary rank, where a commander-in-chief has ten or more ships of the line under his command; it may be compared with that of adjutant-general in the army. He may either be a flag-officer, or one of the senior captains; in the former case, he takes his rank with the flag-officers of the fleet; in the latter, he ranks next to the junior rear-admiral, and is entitled to the pay and compensation of a rear-admiral. All orders of the commander-in-chief are issued through him, and all returns of the fleet through him to the commander-in-chief. He is appointed, and can be removed from his situation only by the Lords Commissioners of the Admiralty.

Commodore. A commodore is a temporary rank, and of two kinds; the one having a captain under him in the same ship, the other without a captain. The former has the rank, pay, and allowances of a rear-admiral, the latter such additional pay as the Lords of the Admiralty may direct. They both carry distinguishing pendants.

Captain. When a captain is appointed to command a ship of war, he commissions the ship by hoisting his pendant; and if fresh out of the dock, and from the hands of the dock-yard officers, he proceeds immediately to prepare her for sea, by demanding her stores, provisions, guns, and ammunition, from the respective departments, according to her establishment. He enters such men as may volunteer, and be fit for the service (in time of peace), or which may be sent to him from some rendezvous for raising men, in time of war; and he gives them the several ratings of petty officers, able-seamen, ordinary, or landsmen, as their apparent qualifications may entitle them to. If he should be appointed to succeed the captain of a ship already in commission, he passes a receipt to the said captain for the ship's books, papers, and stores, and becomes responsible and accountable for the whole of the remaining stores and provisions; and to enable him to keep the ship's accounts, he is allowed a clerk of his own appointing.

The duty of the captain, with regard to the several ship's books and accounts, pay-books, entry, musters, discharges, &c. is regulated by various acts of Parliament; but the state of the internal discipline, the order, regularity, cleanliness, and the health of the crews, will depend mainly on himself and his officers. In all these respects, the general printed instructions for his guidance are particularly precise and minute. And for the information of the ship's company, he is directed to cause the articles of war, and abstracts of all acts of Parliament for the encouragement of seamen, and all such orders and regulations for discipline as may be established, to be hung up in some public part of the ship, to which the men may at all times have access; he is also to direct that they be read to the ship's company, all the officers being present, once at least in every month. He is not authorized to inflict any corporal punishment on any commissioned or warrant officer, but he may place them under arrest, and suspend any officer who shall misbehave, until an opportunity shall offer of trying such officer by a court-martial. He is enjoined to be very careful not to suffer the inferior officers, or men, to be treated with cruelty or oppression by their superiors. He alone is to order punishment to be inflicted, which he is never to do without sufficient cause, nor ever with greater severity than the offence may really deserve; and all the officers and the whole ship's company are to be present at every punishment; which must be inserted in the log-book, and an abstract at the end of every quarter made out and sent to the Admiralty,—a regulation which is said to have been attended with infinite benefit to the strict and just discipline of the naval service.

Lieutenant. The lieutenants take the watch by turns, and are at such times entrusted, in the absence of the captain, with the command of the ship; but he is to inform the captain of all occurrences that take place during his watch, as strange sails that may be in sight, signals from other ships in company, change of wind, &c. He is to see that the ship be properly steered, the log hove, and the course and distance entered on the log-board; and, in short, he is to see that the whole of the duties of the ship are carried on with the same punctuality as if the captain himself were present; in whose absence, the senior lieutenant is responsible for every thing done on board.

Masters. The master receives his orders from the captain, or any of the lieutenants. His more immediate duties are those of stowing the ship's hold, and of attending to her sailing qualities; of receiving and placing the provisions in the ship, so as most conveniently to come at those which may be wanted. He is to take care that the cables are properly coiled in the tiers. The keys of the spirit-room are in his custody, and he is directed to entrust them only to the master's mates. He has the charge of the store-rooms of the warrant officers, which he is ordered frequently to visit; in short, the whole of the ship's provisions, water, fuel, and stores of every description, are under the superintendence of the master; and he is also entrusted, under the command of the captain, with the charge of navigating the ship, bringing her to anchor, ascertaining the latitude and longitude of her place at sea, surveying harbours, and making such nautical remarks and observations as may be useful and interesting to navigation in general.

The warrant officers are charged with the duty of receiving on board from the dock-yards, and examining, the various stores of their respective departments, and of keeping an account of the expenditure of them.

Gunner. The gunner has the charge of the ship's artillery, and of the powder magazine; he is to see that the locks and carriages are kept in good order, and that the powder is preserved from damp; he is frequently to examine the musquetry and small arms, and to see that they are kept clean, and fit for service; and, in preparing for battle, it is his duty to take care that all the quarters are supplied with every thing necessary for the service of the guns, and, during the action, that there be no want of ammunition served out. He is frequently to exercise the men at the guns

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and to see that they perform this part of their duty with correctness, explaining and enforcing the necessity of their pointing the guns before they fire them, of spunging them well, and of close-stopping the touch-hole immediately after firing. The armourer and his mates are under the immediate orders of the gunner, in every thing that relates to the great guns and small arms.

Boatswain.

The boatswain is charged with the duty of receiving and examining all the stores belonging to his department, consisting chiefly of the ropes and rigging, the latter of which he is ordered to inspect daily, in order that any part of it, chafed or likely to give way, may be repaired without loss of time. He is always required to be on deck at such times as all hands are employed; he is to see that the men, when called, move quickly upon deck, and when there, that they perform their duty with alacrity, and without noise or confusion. The sail-maker and the rope-maker are under his immediate orders; and he is directed to see that both these officers perform their respective duties with diligence and propriety.

Carpenter.

The carpenter, when appointed to a ship, is carefully to inspect into the state of the masts and yards, whether in the dock-yard, or on board the ship, to see that they are perfectly sound and in good order. He is to examine every part of the ship's hull, magazine, store-rooms, and cabins. He is every day when at sea carefully to examine into the state of the masts and yards, and to report to the officer of the watch if any appear to be sprung, or in any way defective. He is to see that the ports are secure and properly lined, and that the pumps be kept in good order, as are also the boats, ladders, and gratings. The caulker is placed under his immediate orders, and he is to see that he performs his duty in a workmanlike manner, in stopping immediately any leaks that may be discovered in the sides or decks.

Purser.

The purser has the charge of all the ship's provisions, and the serving them out for the use of the crew. His charge is, therefore, of a most important nature; and, accordingly, he must not only produce good certificates of his conduct while serving in the capacity of clerk, but must also find two sureties for the due discharge of his trust, who are required to give bond in a penal sum, according to the rate or class of ship to which he may be appointed. The regulations and instructions for his guidance are minutely detailed in the general printed instructions, with all the various forms established for the keeping of his accounts with the Victualling Board, to which he is immediately responsible. To assist him in the performance of his arduous duties, he is allowed to employ the clerk, who, though engaged by the captain, who is responsible for the strict performance of the duties of all the officers under his orders, is, as it were, a check on the purser in many parts of his duty, as regards the slop-books, muster-books, &c. He has also a steward under his immediate orders.

Physician, &c.

The duties of the physician to the fleet, the surgeon of a ship and his assistants, the secretary to the commander-in chief, and the chaplain, are too obvious to require any specification.

Midshipmen.

The midshipmen are considered as the principal petty officers, but have no specific duties assigned to them. In the smaller vessels, some of the senior ones are entrusted with the watch; they attend parties of men sent on shore; pass the word of command on board, and see that the orders of their superiors are carried into effect; and, in short, are exercised in all the duties of their profession, so as, after six years service, to qualify them to become lieutenants.

Marines.

Every ship, according to her class, has a certain number of marines serving on board as part of her complement, which are commanded by a captain, or brevet-major, from first to fourth rates inclusive, with three or two subalterns under them, and an established number of non-commissioned officers; but the party on board fifth rates, and under, is commanded by a subaltern, and in small vessels by a serjeant or corporal.

All marine-officers, of whatever rank when embarked, are to obey the orders of the captain, or the commanding officer of the watch. The marines are exercised by their officers in the use of their arms; they are employed as sentinels, and in all other duties on board of which they are capable, with the exception of going aloft. The officer commanding has the charge of the arms, accoutrements, and drums; and he is to inspect weekly, at least, into the state of the clothing of his party. The marines are treated in every respect in the same manner as the rest of the ship's company.

Number of Commissioned Officers.

The long continuance of the revolutionary war necessarily created a prodigious increase of the commissioned officers of the navy. Their numbers, in the four following years of peace, were,

	1793.	1803.	1815.	1821.
Admirals,	11	45	70	63
Vice-Admirals,	19	36	73	59
Rear-Admirals,	19	51	77	68
Post-Captains,	444	666	824	828
Commanders,	160	410	762	776
Lieutenants,	1408	2461	3211	3797

The warrant officers have increased, in each class, from the average of about 400 in 1793, to 700 in 1821.

The number of seamen and marines voted in 1792 was 16,000 (but never reduced to that number), and in 1822, 21,000.

The greatest number of seamen and marines voted in any one year during the war was 150,000.

Ship's Company.

The crew of a ship of war consists of able seamen, ordinary seamen, landsmen, boys, and marines. The landsmen, boys, and marines, are always entered voluntarily, the latter in the same manner as soldiers, by enlisting into the corps, the two former at some rendezvous, or on board particular ships. A supply of boys for the navy is also regularly sent from the Asylum at Greenwich and the Marine Society. Able and ordinary seamen also very commonly volunteer to serve during the war, and always in time of peace; but the high wages given by the merchant ships to seamen in time of war, hold out such encouragement as to induce them to give

the preference to that service, though, in all other respects, their treatment is far superior on board a King's ship; having better provisions, and being subject to much less fatigue and exposure to the weather. Indeed, the excellent regulations now rigidly adhered to on board his Majesty's ships, the attention that is paid to the health and comfort of the crew, have overcome much of that reluctance which formerly was felt to the service of a ship of war.

Health of the Crew.

The state of health on board a King's ship, generally speaking, is not exceeded in the most favoured spot on shore; and that horrible disease, the sea-scurvy, may now be considered as unknown in the British navy, since the universal introduction of lemon juice, or the citric acid, without an ample supply of which no ship is permitted to sail on a foreign voyage. Sir Gilbert Blane, in a sensible little tract on the *Health of the Navy*, says, that he has never seen the scurvy resist the citric acid, and that, in the perusal of several hundreds of surgeons' journals, he has met only with two cases which seemed to resist it. Yet, though it appears to have been known as a remedy for the scurvy, far superior to all others, two hundred years ago, it seems to have lain dormant and utterly neglected till Dr Lind, more than a hundred years afterwards, revived and stated clearly the singular powers of this remedy. In 1600 Commodore Lancaster sailed from England, with three other ships, on the 2d April, and arrived in Saldanha bay on the 1st August. The commodore's crew having each had three table spoonfuls of lemon juice every morning, arrived there in perfect health; whereas the other ships were so sickly, that they were unmanageable for want of hands. We have all felt the commiseration and horror which the perusal of the narrative of *Anson's Voyage* produces. His ship, the Centurion, left England with 400 men, of which 200 were surviving on his arrival at Juan Fernandez, and of these eight only were capable of duty, from scurvy. Yet even this horrible catastrophe seems to have failed in rousing the nation to have recourse to a remedy so certain and efficacious. Cook was well supplied with vinegar and other acids, and found the good effects of them; but the first general supply of lemon juice to the navy was established only in the year 1795, in consequence of a trial that had been made of it the preceding year in the Suffolk of 74 guns. This ship left England, and arrived at Madras in September, without touching at any land. With every man's grog were daily mixed two-thirds of a liquid ounce of lemon juice, and two ounces of sugar. She lost not a man; and though the disease made its appearance in a few, an increased dose of lemon juice immediately removed it. Thus the Suffolk, after a voyage of 162 days, arrived without losing a man, or having a man sick of the scurvy, whereas the Centurion, in 143 days from the last place of her refreshment, lost half of her crew, and the other half so feeble and emaciated, as to be utterly helpless.

Nothing could more strongly point out the efficacy of lemon juice than the following fact. When Lord St Vincent commanded the fleet which blockaded Brest from the 27th May to the 26th September 1800, he maintained so close a blockade, that not a single day passed without reconnoitring the entrance of the harbour; yet, although the seamen of his fleet, consisting of at least 16,000 men, had no other than the ordinary ship's provisions, sixteen only, in the course of four months, were sent to the hospital. In 1780 the Channel fleet, as appears from Dr Lind, were so overrun with scurvy and fever, as to be unable to keep the sea, after a cruize of ten weeks only.

Progressive Diminution of Sickness.

From the official returns collected by Sir Gilbert Blane, M. Dupin, a French author, well versed in naval subjects, has drawn out the following table, which exhibits at one view the progressive diminution of sickness, death, and desertion, in the British navy, calculated on 100,000 men.

Years.	Sent sick to Hospital.	Deaths.	Desertions.
1779	40,815	2651	1424
1782	31,617	2222	993
1794	25,027	1164	662
1804	11,978	1606	214
1813	9,336	698	10

From hence it would appear, that the diminution of sick and of deaths has been in the proportion of 4 to 1 nearly, between the years 1779 and 1813. The diminution of desertions from the hospital in the same period is not the less remarkable; and it affords, at the same time, the strongest proof of the progressive amelioration of the condition of seamen on board British ships of war. Indeed, whether on board ship, or in any of these noble institutions, the Naval Hospitals, which are established at all the principal ports at home, and in the colonies abroad, the attention that is paid to the sick sailor is above all praise. The seamen are sensible of this, and nothing keeps them back from volunteering their services, and from giving a preference to a King's ship over a merchantman, but the temptation of high wages offered by the latter in time of war, and that love of liberty and free scope for roving which are characteristic of seamen.

Manning the Fleet.

The speedy manning of the fleet, on the first breaking out of the war, is one of the most important objects that devolves on the Naval Administration, as by it alone depends the safety of our commerce and our colonies. This has been felt at all times; and, accordingly, a variety of schemes have been brought forward for this purpose, but all of them failed of success, except the compulsory mode of raising men under the authority of press-warrants, issued by the Lords Commissioners of the Admiralty, by virtue of the King's Order in Council, renewed from year to year. There likewise issues, on the breaking out of a war, a proclamation from the King, recalling all British seamen out of the service of foreign princes or states; and the instructions to the commanders of all ships of war direct them to search foreign vessels, and to take British seamen out of them.

Impressment.

The impressment of seafaring men, however anomalous under a free constitution like that of Great Britain, is defensible on state necessity, until it can be

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shown that the fleet, on an emergency, is capable of being manned without resorting to that measure. In consequence of some doubts being raised on the legality of the subject in the year 1676, when the affairs of the Admiralty were managed immediately under the direction of the King and the Great Officers of State, a discussion was held on this point, when it was decided by the Judges and Crown Lawyers, that the King had an indefeasible right to the services of his subjects when the state required them, and that the power of impressing seamen was indispensably inherent in the Crown, without which the trade and safety of the nation could not be secured. The first instance of impressing men in Ireland seems to have been in the year 1678, when the Lord Lieutenant received directions from the Privy Council to raise 1000 seamen for the fleet. In 1690, the Lords Justices of Ireland were directed to assist the officers of the navy in impressing men in that kingdom. In 1697, a register was taken of all the seafaring men in Ireland, which amounted to 4424 men, of whom it is noted 2654 were Catholics. On several occasions, during Queen Anne's reign, the Lords Justices of Ireland received directions to raise men to serve in the fleet.

In Scotland, the mode of raising men by the impress was unknown before the Union; but in various instances the Council of Scotland was directed to raise volunteers for the fleet, each man to have forty shillings as bounty.

In 1706, an experiment was tried for the speedy manning of the fleet, by virtue of an act of Parliament, which required the civil magistrates of all the counties to make diligent search for all seafaring men, and twenty shillings was allowed to the constables for each man taken up; the seamen to have pay from the day of delivery to the naval officers stationed to receive them; and if they deserted after that, were considered as guilty of felony. By the same act, insolvent debtors, fit for the service, and willing to enter it, were released, provided the debt did not exceed L. 30; and no seaman in the fleet was to be arrested for any debt not exceeding L. 20. The whole proceeding under this act incurred a very heavy expence, and totally failed.

In the same year, the Queen referred to the Prince of Denmark, then Lord High Admiral, an address from the House of Lords relating to the three following points:—1st, The most effectual means for manning the fleet. 2d, The encouragement, and increase of the number of seamen. 3d, The restoring and preserving the discipline of the navy. His Royal Highness submitted these points to such of the flag-officers and other commanders as could be assembled, who made a report, of which the substance was to the following effect:—1st, To cause a general register to be kept of all seafaring men in England and Ireland, for which they presented the draft of a bill. 2d, That all marines, qualified to act as seamen, should be discharged from the army, the officers to have levy money and the men's clothing returned. 3d, That not fewer than 20,000 seamen should be kept in employ in time of peace; but, they observe, that as to the restoring and preserving the discipline of the navy, no particular instance being laid before them wherein it was defective, they could give no opinion on that head.

Registry of Seamen.

This registry of seafaring men has been tried more than once, but as the men themselves had no interest whatever in the measure, it always failed in producing the desired effect. The only chance of its succeeding in any prospective emergency is the measure recently adopted by the Lords of the Admiralty, under the sanction of the King in Council,—a measure which was called for on every principle of justice and humanity,—of granting provisions, on the paying off the fleet, to every man who had served fourteen years and upwards. The number thus pensioned amounted at one time to 33,000, and are still not far short of 30,000: and as there are voted for the peace establishment 16,000 men, mostly prime seamen, there is every reason for supposing that less difficulty will be found in manning the fleet, on any future emergency, than heretofore; and that on this account the evils of the impress will be greatly mitigated; for though numbers on the pension list will naturally be unfit for service at sea, most of them will be able to assist in fitting out the fleet.

In fact, there are now so many exemptions from the impress, that its severity is greatly abated. The following description of persons are protected by various acts of Parliament:

Masters of merchant ships or vessels.

First mates of such as are 50 tons or upwards.

Boatswains and carpenters of such as are of 100 tons or upwards.

Men belonging to vessels and craft of all kinds in the employ of Navy, Victualling, Ordnance, Customs, Excise, and Post Offices.

Watermen belonging to the Insurance Offices within the cities of London and Westminster.

All men of the age of 55 years and upwards.

All youths, not having attained the age of 18.

All foreigners.

Apprentices, not having used the sea before the date of their indentures, and not more than three years from the said date.

Landsmen not having served at sea full two years.

Masters, apprentices, one seaman, and one landsman, of all fishing vessels on the sea coast or on navigable rivers.

Harpooners, line-managers, and boat-steerers of the Greenland fishery and the Southern Whale fishery, and all seamen and common mariners who have entered for the said fisheries.

And no person whatsoever can be impressed except by an officer who has been entrusted with a press-warrant.

Discipline.

The discipline of the navy, or the government of his Majesty's ships, vessels, and forces by sea, is regulated by the act of 22d Geo. II., usually known by the name of the Articles of War. By this act, the Lords Commissioners of the Admiralty are empowered to order courts-martial for all offences mentioned therein, and committed by any person in and belonging to the fleet and in full pay; and also to delegate the same power to admirals commanding in chief on foreign stations, which power also may devolve on his successor in case of death or recall, provided that no commander-in-chief of any fleet or

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squadron, or detachment thereof, consisting of more than five ships, shall preside at any court-martial in foreign parts, the officer next in command being ordered to preside thereat.

Courts-Martial.

By this act, no court-martial can consist of more than thirteen or of less than five persons, to be composed of such flag-officers, captains, or commanders then and there present, as are next in seniority to the officer who presides at the court-martial. And when there are but three officers of the rank of post-captains, the president is to call in as many commanders under that rank as will make up five in the whole.

Articles of War.

This code of laws for the government of the fleet consists of thirty-six articles, of which nine award the punishment of death, and eleven death or such other punishment as the court-martial shall deem the offence to deserve. Those which incur the former are, the holding illegal correspondence with an enemy—cowardice or neglect of duty in time of action—not pursuing the enemy—desertion to the enemy—making mutinous assemblies—striking a superior officer—burning magazines, vessels, &c. not belonging to an enemy—murder—sodomy. The penalty of death for cowardice, or other neglect of duty in time of action (Art. 12), and of not pursuing the enemy (Art. 13), was by the 19th Geo. III. so far mitigated, as to authorize the court-martial "to pronounce sentence of death, or to inflict such other punishment as the nature and degree of the offence shall be found to deserve." Under these articles thus mitigated, Admiral Byng would probably not have been condemned to death. The other eleven articles which leave the punishment to the discretion of the court, are, not preparing for fight, and encouraging the men in time of action—suppression of any letter or message sent from an enemy—spies delivering letters, &c. from an enemy—relieving an enemy—disobedience of orders in time of action—discouraging the men on various pretences—not taking care of and defending ships under convoy—quarrelling with and disobeying a superior officer in the execution of his office—wilfully neglecting the steering of ships—sleeping on watch, and forsaking his station—robbery. The remaining sixteen articles incur the penalty of dismissal from the service, or from the ship, degradation of rank, or such other punishment as the court may judge the nature and degree of the offence to deserve.

Petty Punishment.

Much, however, of the internal discipline of a ship of war depends upon the captain, who being empowered to punish the men for minor offences, according to the usage of the service, courts-martial on seamen are rarely found necessary to be resorted to in well regulated ships. The principal circumstance that usually militates against the perfect good order of the crew, is the great allowance of grog served out daily to the men, as established by the King's Order in Council, and which frequently leads to drunkenness, and this to insubordination. Perhaps half the punishments in the navy are for this offence, which requires the utmost vigilance and precautions on the part of the officers to prevent.

Effects of Discipline.

In other respects the discipline of a well organized ship of war is perfect; and to this discipline M. Dupin, a French writer of great sagacity, mainly ascribes the brilliant successes of the British navy, and to the want of it, the ruin of that of France. "We have already cited," says he, "as a model, the management of the *materiel* of the English ships. In the preservation of this *materiel*—in the stowing it away—in the arrangement of whatever may be necessary either for manœuvres or for action, the most perfect regularity is observed. At the same time, what becoming austerity is maintained by the commanding officer; what obedience among the subalterns; and, in a space so limited, considering the number of men on board, and the multiplicity of movements they have to make in obeying so many different orders, what imposing silence! It is the calmness of strength—the presiding influence of wisdom. In the midst of the most complicated operations, and even in the heat and transport of battle, one hears only the words of command, pronounced and repeated from rank to rank, with a measured tone and perfect *sang froid*. No unseasonable advices—no murmurs—no tumult. The commanders meditate in silence; the word is given, and the men act without either speaking or thinking."

This is remarkably so in the day of battle. Every officer and man knows precisely his place, and the duty he has to perform on that day. By the general printed instructions, the captains of his Majesty's ships are required to accustom the men to assemble at their proper quarters, to exercise them at the great guns, to teach them to point, fire, &c. under all circumstances of sea and weather. Indeed, it is well known, that the preservation of the high character of the British navy essentially depends on the proper training of the seamen to the expert management of the guns, so as to be duly prepared in the day of battle; the issue of which so mainly depends on the cool, steady, and regular manner in which the ship's ordnance is loaded, pointed, and fired. Practice in these respects is much more necessary on board ships than on shore, as it can never happen that the ship is entirely steady, and has most frequently a rolling or pitching motion, for which allowances must be made, and which can only be made with effect by long practice.

Naval Tactics.

If the management of the great guns of a ship of war is more difficult than the artillery of a fort, so likewise are naval tactics more difficult than those of an army; inasmuch as there is more difficulty and less dependence in placing and directing the movements of an inanimate than an animate machine. The general principles are the same; the object of both being that of bringing the greatest possible force to bear on that point which is likely to produce the greatest possible injury to the enemy. With this view, as well as to keep a fleet together in compact order, so that straggling ships may not be cut off by the enemy, it has been found necessary to preserve a certain order of sailing, whether out of sight of an enemy or in his presence; and such an order as, according to the state of the wind and weather, and the point of bearing of the enemy's fleet, may most conveniently and expeditiously be changed into such a line of battle as the commander-in-chief may deem it most expedient to adopt in the attack to be made on his opponent.

In order to do this, it is obvious, that every indi-

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vidual captain must be able to know, under all circumstances, what the ship he commands will be able to do, in order to preserve her station in the fleet; for, it is with ships as with horses, no two perhaps performing the same evolution with the same tightness of rein, or the same quantity of sail. This shows the absolute necessity of a commander-in-chief frequently exercising his fleet in naval tactics, and to observe how such and such a ship will behave under a certain quantity of canvass, and to assign her station in the line where she may appear calculated to act with the greatest efficiency.

To facilitate these movements, the admirals commanding squadrons are considered as responsible for the movement of the ships in their respective divisions. They are to see that each captain strictly obeys the general order, and if any one is perceived to neglect his duty, whether belonging to his proper division or not, if in action, he has the power to send immediately another officer to suspend him. And in order that no confusion may arise, if, in time of battle, the admiral commanding in chief, or any of the admirals commanding squadrons, should be killed, his or their flags remain flying till the battle is decided. If the commander-in-chief be killed or severely wounded, a private signal is made to the second in command, or if a junior admiral be killed or wounded, the commander-in-chief is also acquainted by signal.

Code of Naval Signals.

This silent method of communicating what is going on is the perfection of naval tactics; indeed, it is difficult to conceive how our ancestors contrived to manage a fleet without a Code of Signals. For great and important occasions, the exhibition of a flag or flags, in some particular part of the ship, might be generally understood to imply, that the fleet should anchor, or tack, or form the order of sailing in two lines, or the line of battle, or some other great movement. The hoisting of a cask at the yard-arm might be understood to imply a want of water; or a hatchet, of wood; or an empty bag, of bread; and the table-cloth was a very significant invitation to dinner; but they had no means of interchanging freely their wants or intentions, or of conveying detailed intelligence. Even so late as the American war, there was no established code of signals in the navy. An anecdote is told of Admiral Geary, who, in the year 1780, commanded the Channel fleet, which clearly proves how little was then known or practised in the way of signals. His captain, Kempenfelt, had laboured long to improve the defective system; and having one day seen the enemy's fleet, he endeavoured to communicate the intelligence by the new code; but in the hurry of making sail and giving chase, the signals somehow or other were not understood by the rest of the fleet. Geary at last became impatient, and running up to Kempenfelt, seized him by the hand, and exclaimed with great emphasis, "Now, my dear Kempy, do, for God's sake, throw your signals overboard, and make the old one which we all understand,—'to bring the enemy to close action.'"

"If an admiral," says Dr Beatson in his able *Memoirs*, "cannot command all the necessary movements of his ships by signal in the day of battle, he is not upon a footing with an enemy who possesses that advantage, and even with better ships and better men, and more experienced commanders, he may be foiled in his expectations of victory, if not defeated, from his want of the means to direct, and to perform the necessary evolutions of his fleet." "In no fight," he adds, "was the insufficiency of the present system of naval signals more conspicuous than in this (Keppel's unfortunate action); and it is to be hoped that if ever a new code be adopted for the use of the royal navy, it may be so clear and comprehensive, that such fatal errors as those which have been pointed out will in future be prevented." This we may now say has been accomplished.

The idea of *numbering* the flags, and of assigning a certain number of corresponding sentences to certain combinations of these numbers, was reduced to something approaching a regular system in the fleet under the command of Lord Howe; and in the year 1798 a new signal book was issued from the Admiralty, containing about 400 sentences, expressive of certain operations of a fleet, communicated by means of flags to which the numerical characters were applied, and these, as far as they went, answered very well, but did not supersede the necessity of conveying orders by boats on many occasions. The following year Sir Home Popham suggested the idea of making the flags to represent the letters of the alphabet in combination with numbers, which not only added immensely to the means of communication, but also of making use of words by signal. From this time improvements in the modes of communicating by signals and telegraphs were rapidly introduced; particularly in the shape and the colours of the flags, according to a plan of Sir Home Popham, which has rendered signals by flags as nearly perfect as they probably ever will be.

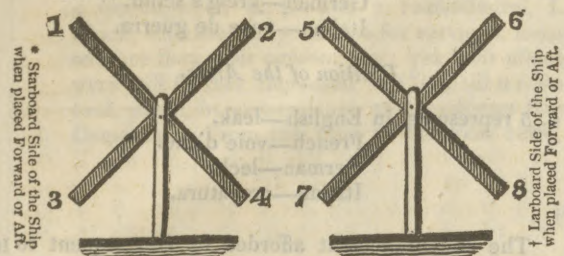
There is, however, an imperfection in the flags themselves; as in calm weather when they do not fly out, neither their shape nor colour is visible without the use of stretchers, which are not always easily managed, and never without loss of time. Again, if the wind be parallel to the line of vision, the flag shows only its edge, and neither shape nor colour can be discerned. To remedy these inconveniencies, Sir Home Popham proposed a portable wooden semaphore in imitation of the French telegraph, to be mounted on the quarter-deck or poop of a ship.

Sea Telegraph.

It consists of two posts, each having a moveable arm, which may be placed in four positions that can never be mistaken, being at right angles to each other, as in the following figures, where the number annexed to each position is that which it conveys to the person receiving the message.

SEA TELEGRAPH.

Foremost Post. * Aftermost Post. †



Combinations.

The *left* hand of each column represents the numbers which are exhibited by the arms either singly or in combination.

The *right* hand of each column represents the characters of the telegraphic signals, which are exhibited by the positions of the arms placed opposite to them.

The cornettes, triangles, and pendants, are those used in the common signals, which in the book represent the letters opposite to each.

Position 1 *represents*	*Flag*	1
2		2
3		3
4		4
5		5
6		6
7		7
8		8
1. 5		9
1. 6	*Cornette*	A
1. 7		B
1. 8		C
2. 5		D
2. 6		E
2. 7	*Triangle*	F
2. 8		G
3. 5		H
3. 6		I
3. 7		K
3. 8	*Pendant*	L
4. 5		M
4. 6		N
4. 7		O
4. 8	*Finish.*	

Auxiliary Signs.

These signs always represent the subjects placed opposite to them—for instance, when the alphabetical sign is made, the subsequent positions of the arms will represent the letters of the alphabet until the stop is made. The same with numbers, ships' names, &c. as particularly explained in the instructions of the Telegraphic Signal Book. The *Stop* and the other *Auxiliary Signs* must be placed *exactly horizontal.*

Spelling Alphabet.
Representative Sign.

Positions of the Arms.	Letters.
1 *represents*	A
2	B
3	C
4	D
5	E
6	F
7	G
8	H
1. 5	I & J
1. 6	K
1. 7	L
1. 8	M
2. 5	N
2. 6	O
2. 7	P
2. 8	Q
3. 5	R
3. 6	S & Z
3. 7	T
3. 8	U & V
4. 5	W
4. 6	X
4. 7	Y

Numeral
Representative Sign.

Positions of the Arms.	Numbers.
1 *represents*	1
2	2
3	3
4	4
5	5
6	6
7	7
8	8
1. 5	9
1. 6	0

Horizontal Signs.	Significations of the Horizontal Signs.
	General Preparative.
	Ships' Names.
	Alphabet.
	Numeral.
	Annul, and Negative.
	Local Table.
	Message not understood.
	Affirmative.

Navy.

The mode of applying a Secret Key for RECEIVING *and* COMMUNICATING *Messages is extremely simple, as for instance,*

Communicating.		Receiving.	
Characters of Telegraph Book.	Positions of Arms.	Positions of the Arms.	Characters of Telegraph Book.
1	6	1	4
2	2	2	2
3	7	3	L
4	1	4	O
5	1. 6	5	8
6	3. 6	6	1
7	8	7	3
8	5	8	7
9	2. 5	1. 5	A
A	1. 5	1. 6	5
B	2. 8	1. 7	C
C	1. 7	1. 8	F
D	3. 5	2. 5	9
E	3. 8	2. 6	K
F	1. 8	2. 7	N
G	4. 5	2. 8	B
H	4. 7	3. 5	D
I	4. 6	3. 6	6
K	2. 6	3. 7	M
L	3	3. 8	E
M	3. 7	4. 5	G
N	2. 7	4. 6	I
O	4	4. 7	H
		4. 8	Finish.

It is obvious, that, by a combination of letters and numerals, messages to any extent may be made either by a collection of certain sentences, or a vocabulary of words, or by spelling; the last mode being the least objectionable, though not the most expeditious, unless in very short sentences. For instance, if, on meeting a ship at sea, her name was asked by telegraph, and the answer was No. 8, which, on reference to the list of the navy, was the Hero, but by some mistake, owing to haze or other accident (which will sometimes happen to the best observers), the parallel position No. 4 was read off, opposite to which was the Bellerophon, there would be no possible means of correcting the mistake; but if the first name was spelled by the alphabetic signs, the very first signal, 8, being H, would be sufficient, but the remaining 5—3.5—2.6 would not require many seconds to remove any doubt, if no list of the navy happened to be on board. When signal flags are used, spelling is the more advisable, as the shape and colours of a flag are more liable to be mistaken.

A Polyglot Telegraph.

This simple machine might be made the means of intelligible communication in all the languages of Europe, and its utility thus become universal. For instance, if a French or Spaniard should see an English ship, their wants and wishes may easily be interchanged, although the master of the one should be totally ignorant of the language of the other; that is to say, provided the established telegraph book was translated into their respective languages: for example,

Position of the Arms.

3. 6 represents, in English—man of war.
French—vaisseau de guerre.
German—kreig's schiff.
Italian—nave de guerra.

Position of the Arms.

4. 5 represents, in English—leak.
French—voie d'eau.
German—leck.
Italian—crepatura.

Improvement in Navigation.

The encouragement afforded by Government to every branch of science connected with the navy, and navigation in general, has been carried much farther by England than any other Enropean nation; and has produced the happiest results for commercial enterprise—by determining with accuracy the precise position of ships—by shortening long voyages—and by the discovery of new lands and unexplored regions. From the commencement of the eighteenth century, when a national reward was first offered to the man of science, or the artist who should discover a method sufficiently exact to determine the longitude of a ship's place at sea, to the present time, the improvements in the construction and division of all kinds of instruments for measuring angles, in the calculations of lunar and other tables, and above all, in the manufacture and adjustments of chronometers, have continued in gradual progression; and may now be considered to have arrived at such a degree of perfection, more especially the chronometers, that the discovery of the longitude can scarcely be said to remain a desideratum. We may form an idea what the progress in the improvement of chronometers has been, when a public reward was offered by Parliament in the year 1814 to the first who should determine the longitude at sea *within a degree*, and in 1820, three chronometers, after remaining in the Arctic regions for eighteen months, returned to England without altering their rates more than a few seconds of time.

Increase of Science in the Navy.

The officers of the Royal Navy are much more generally versed in the sciences of late years than heretofore. In fact, it is now necessary for a young man to be well acquainted with a certain portion of mathematical and astronomical knowledge, to enable him to pass an examination, without which he cannot be qualified for the commission of a lieutenant. The Royal Naval College of Portsmouth, for the education of a certain number of youths, has been the means of introducting a better system of naval education into his Majesty's ships of war. The examinations also of the several warrant officers and their qualifications for their respective stations, are more strictly attended to than heretofore; and the consequence is, that a much better system of discipline without rigour, is established throughout the fleet, and more comfort in every respect to every class of officers and men employed.

Pay and Emoluments.

The encouragement given to the navy from its first regular establishment, has marked it as a favourite service in the minds of the public. The sea-pay, the half-pay, and other emoluments, have gene-

rally been superior to those enjoyed by the army, but subject to great fluctuations in every reign, and to frequent changes in the same reign. Thus King William, in 1693, gave to an admiral, L. 4 a day—a vice-admiral, L. 3—and a rear-admiral, L. 2—which, with the compensation for servants, amounted to more than their present pay; yet their allowances were still further increased in 1700, till a reduction took place, in consequence of an address from the Commons. From this time to the year 1806, very little alteration took place, when a small addition was made to the pay of each class.

The following table will exhibit, at one view, the complete war-establishment of commission, warrant, petty, and non-commissioned officers, seamen, and marines, on board every class of his Majesty's ships, with the rate of pay granted to each, and the classes into which they are divided for the distribution of prize-money or seizures; as established by his Majesty's Order in Council of the 25th November 1816:

FLAG PAY.

Admiral of the Fleet	L. 6	0	0	SEA PAY *per diem*, besides which every Commander-in-Chief receives a further sum of L. 3 *per diem*, while his Flag may be flying within the limits of his Station.
Admiral	5	0	0	
Vice-Admiral	4	0	0	
Rear-Admiral or Commodore with Captain under him; Captain of the Fleet	3	0	0	

In Flag Ships all the Lieutenants (including one extra as Flag Lieutenant) are allowed 6d. *per diem* in addition to their pay.

Classes for Distribution of Seizures.		L.	s.	d.	
II.	Physician to the Fleet of less than three Years service as such	1	1	0	*per Diem.*
	Physician to the Fleet of more than 3, and less than 10 Years Service	1	11	6	Do.
	Physician to the Fleet of more than 10 Years Service	2	2	0	Do.
	Master of the Fleet	15	7	0	*per Mensem.*
III.	Secretary to the Admiral of the Fleet	38	7	0	Do.
	Secretary to an Admiral Commander-in-Chief	30	13	8	Do.
	Secretary to a Vice or Rear Admiral Commander-in-Chief	23	0	4	Do.
	Secretary to a Junior Flag Officer or Commodore	11	10	0	Do.
IV.	Two Clerks to Secretaries of Commanders-in-Chief, each	4	12	0	Do.
	One Clerk to Secretaries of Junior Flag Officers or Commodores	3	16	8	Do.
	Admiral's Coxswain	2	9	0	Do.
VII.	Steward, Cook, Domestics *	1	12	0	Do.

* The numbers of these Ratings to be		
	Admiral of the Fleet	12
	Admiral	10
	Vice-Admiral	7
	Rear-Admiral, or Commodore with Captain under him	5
	Captain of the Fleet	3

Classes for Distribution of Seizures in Ships and Sloops.	RANKS AND RATINGS.	1st Rate.				2d Rate.				3d Rate.				4th Rate.			
		No	Pay per Mensem.			No	Pay per Mensem.			No	Pay per Mensem.			No	Pay per Mensem.		
			L.	s.	d.		L.	s.	d.		L.	s.	d.		L.	s.	d.
I.	Captain	1	61	7	4	1	53	14	0	1	46	0	8	1	38	7	0
	1st Lieut. if of 7 years standing	8	11	10	0	7	11	10	0	6	11	10	0				
II.	All others		9	4	0		9	4	0		9	4	0	5	9	4	0
	Master	1	13	0	8	1	12	5	4	1	11	10	0	1	10	14	8
	2d Master	1	5	7	4	1	5	7	4	1	5	7	4	1	5	7	4
	Chaplain	1	12	5	4	1	12	5	4	1	12	5	4	1	12	5	4
	Purser	1	5	7	4	1	4	12	0	1	4	12	0	1	4	4	4
	Surgeon (for Pay see Note at the end of this Table)	1				1				1				1			
III.	Gunner	1				1				1				1			
	Boatswain	1	7	13	4	1	6	18	0	1	6	2	8	1	5	7	4
	Carpenter (with 7s. per Mensem additional for Tools in every rate)	1				1				1				1			
	Master's Mate, if passed	6	4	12	0	4	4	4	4	3	4	4	4	2	3	16	8
	Master's Mate, not passed		3	16	8		3	9	0		3	1	4		2	13	8
	Midshipman, if passed	24	3	16	8	20	3	9	0	16	3	9	0	10	3	1	4
	Midshipman, not passed		2	13	8		2	6	0		2	6	0		1	18	4
	Assistant Surgeon (for Pay see Note)	3				3				2				2			
	Clerk	1	4	12	0	1	4	4	4	1	4	4	4	1	3	16	8
	Schoolmaster	1				1				1				1			
	Master at Arms	1				1				1				1			
	Armourer	1				1				1				1			
	Caulker	1				1				1				1			
	Rope Maker	1	2	10	0	1	2	8	0	1	2	6	0	1	2	4	0
	Sail Maker	1				1				1				1			
IV.	Carpenter's Mate (with 7s. per Mensem additional for Tools in every rate)	2				2				2				2			
	Gunner's Mate	5				4				3				2			
	Boatswain's Mate	8				7				6				4			
	Ship's Corporal	2				2				2				2			
	Quarter Master	12				12				9				6			
	Captain's Coxswain	1	2	4	0	1	2	3	0	1	2	1	0	1	1	19	0
	Coxswain of the Launch	1				1				1				1			
	Coxswain of the Pinnace	1				1				1							
	Yeoman of the Signals	1				1				1				1			
	Captain of the Hold	1				1				1				1			
	Captain of the Forecastle	3				3				3				2			
	Cooper	1				1				1				1			
	Armourer's Mate	2	2	4	0	2	2	3	0	2	2	1	0	1	1	19	0
	Caulker's Mate	1				1				1				1			
	Sailmaker's Mate	1				1				1				1			
V.	Captain of the Foretop	3				3				3				2			
	Captain of the Maintop	3	1	19	0	3	1	18	0	3	1	17	0	2	1	16	0
	Captain of the Afterguard	3				3				3				2			
	Captain of the Mast	3				3				3				2			
	Ship's Cook	1	2	11	6	1	2	11	6	1	2	11	6	1	2	11	6

5th Rate.		6th Rate.		Sloops. 100 Men & upwards.		Sloops. Under 100 Men.		Bombs.		Gun Brigs.		Schooners & Cutters.		Classes for Distribution of Seizures in Brigs, Schooners, and Cutters.
No	Pay per Mensem.	No	Pay per Mensem.	No	Pay per Mensem.	No	Pay per Mensem.	No	Pay per Mensem.	No	Pay per Mensem.	No	Pay per Mensem.	
	L. s. d.		L. s. d.		L. s. d.		L. s. d.		L. s. d.		L. s. d.		L. s d.	
1	30 13 8	1	26 17 0	1	23 0 4	1	23 0 4	1	23 0 4					
4	9 4 0	3	9 4 0	2	9 4 0	2	9 4 0	2	9 4 0	1	11 10 0	1	11 10 0	I.
1	9 4 0	1	8 8 8	1	7 13 4	1	7 13 4	1	7 13 4	1	7 13 4	1	7 13 4	II.
1	4 12 0	1	4 12 0											
1	12 5 4	1	12 5 4											
1	4 4 4	1	3 16 8	1	3 16 8	1	3 16 8	1	3 16 8					
1		1		1		1		1						
1		1		1		1		1						
1	4 19 8	1	4 12 0	1	4 12 0	1	4 12 0	1	4 12 0					
1		1		1		1		1						
2	3 9 0	2	3 9 0	1	3 9 0	1	3 9 0	1	3 9 0	1	3 9 0	1	3 9 0	
	2 13 8		2 13 8		2 13 8		2 13 8		2 13 8		2 13 8		2 13 8	
8	3 1 4	6	3 1 4	2	3 1 4	2	3 1 4	2	3 1 4	1	3 1 4	1	3 1 4	III.
	1 18 4		1 18 4		1 18 4		1 18 4		1 18 4		1 18 4		1 18 4	
1		1		1		1		1		1		1		
1	3 9 0	1	3 9 0											
1		1		1	3 9 0	1	3 9 0	1	3 9 0	1	3 9 0	1	3 9 0	
1		1												
1		1		1		1		1						
		1		1		1		1						
1	2 2 0	1	2 0 0	1	1 19 0	1	1 19 0	1	1 19 0					
1		1		1		1		1						
		1		1		1		1		1	1 19 0	1	1 19 0	
2		2		2		2		1		1		1		
2		2		2		2		1		1		1		
3		1		1		1		1		1		1		
2		3		3		2		2						
5		1		1		1		1		1		1		
1	1 17 0		1 15 0		1 15 0		1 15 0		1 15 0		1 15 0		1 15 0	IV.
1														
1														
1														
2		2		2		1		1						
1		1		1		1		1						
1	1 17 0	1	1 15 0	1	1 15 0	1	1 15 0		1 15 0	1	1 15 0	1	1 15 0	
1		1												
2		2		2		1		1						
2	1 15 0	2	1 14 0	2	1 14 0	1	1 14 0		1 14 0					V.
2		2		1										
2		2		1										
1	2 11 6	1	2 10 6	1	2 10 6	1	2 10 6	1	2 10 6	1	2 10 6	1	2 10 6	

Classes for Distribution of Seizures in Ships and Sloops.	RANKS AND RATINGS.	1st Rate. No	1st Rate. Pay per Mensem. L. s. d.	2d Rate. No	2d Rate. Pay per Mensem. L. s. d.	3d Rate. No	3d Rate. Pay per Mensem. L. s. d.	4th Rate. No	4th Rate. Pay per Mensem. L. s. d.
VI.	Volunteer 1st Class	8	1 0 0	7	1 0 0	6	1 0 0	4	1 0 0
	Gunner's Crew	25	1 14 0	22	1 14 0	20	1 14 0	13	1 14 0
	Carpenter's Crew (with 7s. per mensem additional for tools in every rate)	18		16		14		12	
	Sailmaker's Crew	2		2		2		2	
	Cooper's Crew	2		2		2		2	
	Able Seaman		L.1, 12s. in all Rates.		The numbers included in these ratings are in				
	Gunner's Yeoman								
	Boatswain's Yeoman								
	Carpenter's Yeoman								
	Ordinary Seaman		L.1, 4s. in all Rates.						
VII.	Cook's Mate								
	Barber								
	Purser's Steward (in vessels in which a purser is allowed)		L.1, 12s. in all Rates.						
	Captain's Steward								
	Captain's Cook								
	Ward or Gun-room Steward								
	Ward or Gun-room Cook								
	Steward's Mate		L.1, 1s. in all Rates.						
	Landman								
VIII	Boy 2d Class	13	0 12 3	12	0 12 3	10	0 12 3	7	0 12 3
	Ditto 3d Class	18	0 10 9	17	0 10 9	16	0 10 9	11	0 10 9
	Widow's Men	9	1 12 0	7	1 12 0	6	1 12 0	5	1 12 0
	Total	207		188		166		126	

No	5th Rate. Pay per Mensem. L. s. d.	No	6th Rate. Pay per Mensem. L. s. d.	No	Sloops. 100 Men & upwards. Pay per Mensem. L. s. d.	No	Sloops. Under 100 men. Pay per Mensem. L. s. d.	No	Bombs. Pay per Mensem. L. s. d.	No	Gun Brigs. Pay per Mensem. L. s. d.	No	Schooners & Cutters. Pay per Mensem. L. s. d.	Classes for Distribution of Seizures in Brigs, Schooners, and Cutters.
4	1 0 0	3	1 0 0	3	1 0 0	2	1 0 0	1	1 14 0	2	1 14 0	2	1 14 0	VI.
10, 8, 1, 1	1 14 0	8, 6, 1, 1	1 14 0	6, 4, 1, 1	1 14 0	4, 2, 1	1 14 0							

			Making the total War Complement of	Classes
1st Rates	1st Class	533	900	VI.
	2d Class	483	850	
	3d Class	433	800	
2d Rates	1st Class	362	700	
	2d Class	312	650	
3d Rates	1st Class	359	650	
	2d Class	309	600	
4th Rates	1st Class	264	450	VII.
	2d Class	164	350	
5th Rates	1st Class	144	300	
	2d Class	124	280	
6th Rates	1st Class	63	175	
	2d Class	33	145	
	3d Class	13	125	
Sloops, Brigs, &c.	1st Class	50	135	
	2d Class	40	125	
	3d Class	36	95	
	4th Class	16	75	
	5th Class	30	60	
		20	50	

No	5th Rate	No	6th Rate	No	100 Men & upwards	No	Under 100 men	No	Bombs	No	Gun Brigs	No	Schooners & Cutters	Classes
6	0 12 3	5	0 12 3	4	0 12 3	2	0 12 3	1	0 12 3	1	0 12 3	1	0 12 3	VIII.
10	0 10 9	9	0 10 9	6	0 10 9	2	0 10 9	5	0 10 9	2	0 10 9	2	0 10 9	
3	1 12 0	2	1 12 0	1	1 12 0	1	1 12 0	1	1 12 0					
106		87		65		47		34		18		18		

Classes for Distribution of Seizures in Ships and Sloops.	RANKS AND RATINGS.	Number in each Rate. 1st Rate.	2d Rate.	3d Rate.	4th Rate.	5th Rate.	6th Rate.	Sloops, 100 Men & upwards.	Ditto, under 100 Men.	Bombs.	Gun-Brigs.	Schooners and Cutters.	Pay of Marines, in all Rates.	Pay of Marine Artillery.
	MARINES.													
II.	Captain	1	1	1	1								14 14 10	15 8 0
	Do. if Brevet Major												17 10 10	18 4 0
III.	1st Lieutenant													
	Do. after 7 years	3	3	2	1	2	1			1			10 10 7	10 19 4
	Do. under 7 years												9 2 4	9 11 4
	2d Lieutenant												7 7 5	7 16 4
IV.	Serjeant	4	3	3	2	2	1	1	1	1	1	1	1 18 1	2 16 9
	Do. if Colour Serjeant												2 12 1	3 10 9
V.	Corporal	4	3	3	2	1	1	1	1	1	1	1		
	Do. after 14 years												1 10 1	2 14 0
	Do. from 7 to 14 years												1 7 9	2 11 8
	Do. under 7 years												1 5 5	2 9 4
VI.	Drummer	2	2	2	1	1	1	1					1 1 4	1 4 5
	Bombardier													
	Do. after 14 years									1				2 9 6
	Do. from 7 to 14 years													2 7 2
	Do. under 7 years													2 4 10
	Private or Gunner													
	Do. Do. after 14 years	146	138	114	53	44	21	17	10	10	10	10	1 1 6	1 9 1
	Do. Do. from 7 to 14 do.												0 19 2	1 6 9
	Do. Do. under 7 years												0 17 5	1 4 5
	Total Marines	160	150	125	60	50	25	20	12	14	12	12		

Note.—To this Table it may be added that Captains, who, on the death or absence of a Commander-in-Chief, are authorized to hoist a distinguishing pendant, are entitled to receive the pay of L. 1 *per diem* in addition to their pay as Captains, while the pendant is flying within the limits of the station.

Surgeons of Ships in Active Service.

Under	6 years service	10s.	a-day.
After	6 ditto	11s.	do.
—	10 ditto	14s.	do.
—	20 ditto	18s.	do.

Surgeons in Receiving-Ships, Prison-Ships, &c.

In harbour duty	10s.	a-day.
Surgeons of hospital ships	15s.	do.
Assistant-surgeons	6s. 6d.	do.

Establishment of Half-Pay.

Though the navy, as we have seen, was put upon a regular establishment under the reign of Henry VIII., neither officers nor seamen had any pay or emolument in time of peace, until the reign of Charles II.; when, in 1668, certain allowances were made to flag-officers and their captains out of the L. 200,000 a-year voted for the whole naval service; and in 1674, certain other allowances were granted by Order in Council, to captains who had commanded ships of the 1st and 2d rate, and to the second captains to flag-officers, on the ground, as assigned in the preamble, that they had undergone the brunt of the war, without sharing in the incident advantages of it, as prizes, convoys, and such like, which the commanders of the smaller classes of ships had enjoyed. But the first regular establishment of half-pay for all flag-officers, captains, first-lieutenants, and masters, was, by King William, in the year 1693, provided they had served a year in their respective qualities, or had been in a general engagement with the enemy. A regular established half-pay was further sanctioned by Order in Council of Queen Anne in 1700; the conditions of which were, that no officer should enjoy the benefit thereof who shall absent himself without permission of the Lord High Admiral or Lords Commissioners of the Admiralty, or who shall be dismissed for any misdemeanour, or by court-martial, or who shall not behave himself to the

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satisfaction of the Lord High Admiral, or who shall have leave to go out of his Majesty's dominions, if employed in the merchant service or otherwise, or if he enjoys the benefit of any public employment. Since the above period the rate of half-pay to the several officers of the navy has undergone various modifications. At present, it stands as under:

RATES OF HALF-PAY.

Flag-Officers.

	Per Diem.		
Admirals of the Fleet	L. 3	3	0
Admirals	2	2	0
Vice-Admirals	1	12	6
Rear ditto	1	5	0

Captains.

To each of the first 100 as they stand on the general list of officers in seniority	0	14	6
To each of the next 150	0	12	6
To the rest	0	10	6

Commanders.

To each of the first 150 on the list	0	10	0
To the remainder	0	8	6

Lieutenants.

To each of the first 300 on the list	0	7	0
To each of the next 700	0	6	0
To the remainder	0	5	0

Royal Marines.

Colonels	0	14	6
Lieutenant-Colonels	0	11	0
Majors	0	9	6
Captains	0	7	0
First Lieutenants of 7 years standing	0	4	6
The rest	0	4	0
Second Lieutenants	0	3	0

Masters.

To the first 100 on the list (being qualified for first or second rates)	0	7	0
To the next 200 (being qualified for third or fourth rates)	0	6	0
The remainder having served 5 years in the navy, 2 of which as acting or second master, or as master's mate or midshipman	0	5	0

Medical Officers.

Physicians—After 10 years service	1	1	0
3 years	0	15	0
Under that time	0	10	6

Surgeons.

Six years service	0	6	0
Under that time	0	5	0

Assistant Surgeons.

Three years service	0	3	0
Two years	0	2	0
Dispensers	0	5	0

Chaplains. *Per Diem.*

After eight years service at sea, or ten in harbour	L. 0	5	0
For less service, not under 3 years	a proportion of the above.		
For each year's longer service than ten years, 6d. *per diem* additional till it reach	0	10	0

Pursers.

To the first 100 on the list	0	5	0
Do. next 200 do.	0	4	0
The remainder	0	3	0

Payable Quarterly.

The boatswains, gunners, and carpenters of the navy, have pensions or superannuations, in lieu of half-pay, according to the following scale, formed on a consideration of the total length of service as warrant officers, with the length of service in commission.

Total Service. Years.	Commissioned Service. Years.	Pension. L.
30	20	85
30	15	75
30	10	65
30	5	55
20	20	75
20	15	65
20	10	55
20	5	45
15	15	60
15	10	50
15	5	40
10	10	45
10	5	35

Naval Prize-Money.

In point of half-pay and other pecuniary emoluments, the navy has much the advantage over the army, more particularly in the chance of prize-money, which but seldom falls to the share of the army, except on some conjoint expedition. On the commencement of a war a proclamation is issued by the King, directing that the net produce of all prizes taken by any of his ships of war, shall be for the entire benefit and encouragement of the flag-officers, captains, commanders, and other commissioned officers, and of the seamen, marines, and soldiers on board at the time of the capture; and directing also in what manner the distribution shall be made. Many very handsome and, in some instances, very splendid fortunes have been made by captures of the enemy's ships.

Honours and Rewards.

Another great encouragement for young men to enter the naval service arises from the honours bestowed by the Sovereign for any brilliant exploit. Thus, in consequence of the skill and bravery which were exhibited in the great and glorious action of the 1st of June 1794, his Majesty was graciously pleased to confer on Earl Howe the Order of the Garter; Vice-Admirals Graves and Sir Alexander Hood were made Barons of the Kingdom of Ireland; and Rear-Admirals Bowyer, Gardner, and Pasley, together with Sir Roger Curtis, Captain of the Queen Charlotte, were created Baronets. Gold medals and

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chains were also distributed to such admirals, and gold medals to such captains, as were particularized in Lord Howe's dispatches. The first lieutenants of each ship were promoted to the rank of commanders; and pensions of L. 1000 *per annum* were granted to Rear-Admirals Bowyer and Pasley.

For the action of 14th February 1797, Lord St Vincent was advanced to the dignity of an Earl, and a pension granted to him of L. 3000 a-year; Vice-Admirals Thompson and Parker were created Baronets; Commodore Nelson received the Order of the Bath, and Captain Calder of the Victory, the honour of Knighthood; and gold medals were distributed to the admirals and captains.

For the action of the 11th October 1797, Admiral Duncan was created a Viscount, with a pension of L. 2000 a-year; Vice-Admiral Onslow made a Baronet, and Captain Fairfax had the honour of Knighthood. Gold medals were also distributed to the admirals and captains.

For the action of the 1st August 1798, his Majesty was pleased to testify his sense of the importance of this brilliant achievement, by raising Sir Horatio Nelson to the dignity of the Peerage, by the title of Baron Nelson of the Nile; and by directing medals to be distributed to the captains. The first lieutenant of the Majestic was made a post-captain, and the first lieutenants of the other ships were promoted to the rank of commanders. And for the attack of the Danish fleet at Copenhagen; Lord Nelson was raised to the dignity of a Viscount, and on Admiral Graves was conferred the Order of the Bath.

For the ever memorable action of Trafalgar, in which Lord Nelson fell in the arms of victory, his Majesty was pleased to confer on his brother the rank of an Earl, with a pension of L. 5000 a-year; and the sum of L. 120,000 was voted by Parliament for the purchase of an estate to be annexed to the title. Admiral Collingwood was raised to the dignity of a Baron; Lord Northesk was honoured with the Order of the Bath, and Captain Hardy was created a Baronet. The captains had medals; five lieutenants were made post-captains; 24 lieutenants, commanders; 22 midshipmen were made lieutenants; and the senior captain of marines made brevet-major.

By this last act of Lord Nelson's life was annihilated the last remaining hope of the combined navies of France and Spain, and a blow given to the naval power of the enemies of Great Britain, which they never recovered during the remainder of the war.

In the minor victories of Sir John Warren, Sir John Duckworth, Sir Robert Calder, Sir Richard Strachan, Lord Gambier, and Lord Exmouth, and even for brilliant actions of single ships, appropriate distinctions have never been withheld. Exclusive of peerages and baronetcies, the honours bestowed for gallant conduct in the naval service consist of 25 Grand Crosses of the Bath, 70 Knights Commanders, and 130 Companions of the Bath.

Pensions for Wounds.

The provision which is made for officers, in the event of losing a limb, or being so severely wounded in the service, as to be of equal prejudice to the habit of body with the loss of a limb, is another encouragement for entering the naval service.

For an admiral, from L.300 to L.700 *per annum*.
A post-captain, wounds, L.250, loss of a limb, L.300.

Commander,	do.	L.150,	do.	L.200.
Lieutenant,	do.	L.91, 5s.	do.	L.91, 5s.

Marine officers the same as in the army.

Widows' Pensions.

A provision is likewise made for the widows of the commission and warrant officers of his Majesty's navy, under the title of the "Widow's Charity," the management of which is vested in a Court of Assistants annually chosen, consisting chiefly of the Lords Commissioners of the Admiralty (the First Lord being President), and the flag-officers of the navy, making in the whole eighteen.

The funds arise from, 1. A deduction of threepence in the pound from the pay, half-pay, and pensions of the commission and warrant officers of the navy. 2. The amount of the wages and value of the victuals of *one* fictitious man in every 100, borne on the books of ships in sea-pay. And, 3. Interest of the capital vested in the funds. During the late war, the amount of the revenue from these sources was from L.90,000 to L.100,000; and the amount of pensions were about L.70,000 a-year. The pensions are allowed according to the following scale, being similar in most cases to the widows of officers in the army of corresponding ranks: the latter are provided for by an annual vote of Parliament.

Scale of Pensions.

The widow of a Flag-Officer of his Majesty's fleet,	L.120	0	0
——— of a Captain, superannuated with the rank of Rear-Admiral,	100	0	0
——— of a Post-Captain, of three years standing,	90	0	0
——— of a Post-Captain, under three years standing,	80	0	0
——— of a Commander,	70	0	0
——— of a Lieutenant, superannuated with the rank of Commander,	60	0	0
——— of a Lieutenant,	50	0	0
——— of a Master,	40	0	0
——— of a Surgeon,	40	0	0
——— of a Purser,	30	0	0
——— of a Boatswain,	25	0	0
——— of a Gunner,	25	0	0
——— of a Carpenter,	25	0	0
——— of a Second Master of a Yacht, or Master of a Naval Vessel warranted by the Navy Board,	25	0	0

And the widows of officers of the Royal Marines are entitled to the following pensions:

		Per Annum.		
The Widow of a	General Officer,	L.120	0	0
Do.	Colonel,	90	0	0
Do.	Lieutenant-Colonel,	80	0	0
Do.	Major,	70	0	0
Do.	Captain,	50	0	0
Do.	First Lieutenant and Surgeon,	40	0	0
Do.	Second Lieutenant and Assistant-Surgeon,	30	0	0

Compassionate Fund.

In addition to these pensions, there has recently

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been established a *Compassionate Fund*, for the relief of such widows and orphan children as may appear to be objects of compassion. The sums annually required are voted by Parliament, and at present do not exceed from L.6000 to L.7000 a-year.

Provision for Seamen.

No provision, however, had been made for the brave seamen who fought the battles of their country, excepting for such as had been wounded in fight with the enemy. In the year 1588, after the memorable defeat of the Spanish Armada, the wounded seamen petitioned Elizabeth for relief, upon which, with the advice of the Lord High Admiral and the Commissioners of the Navy, and with the consent of the inferior officers and seamen, the sum of sixpence a month was deducted out of the wages of warrant officers and seamen, for the relief and maintenance of such as were hurt or maimed in the service. The money so raised was deposited at Chatham in a chest, under the superintendence of the Yard Officers and the Warrant Officers of the Navy. As the funds increased, the management of them was transferred to certain Commissioners and Governors; and in order to do away in some measure the inconvenience of compelling seamen from the western ports to go to Chatham for their pensions, the chest was removed, by the 43d Geo. III. to Greenwich Hospital; and the power and authorities of the former trustees were vested in the First Lord of the Admiralty, the Comptroller of the Navy, the Governor of Greenwich Hospital, and the Auditor of the same hospital, all for the time being, who, by this act, are created a body politic and corporate, by the name of the *Supervisors of the Chest of Greenwich;* the said supervisors to appoint five *Directors* from the officers of Greenwich Hospital, to have the immediate management of the business.

In the course of the late war the funded property amounted to nearly L.1,000,000 in the 3 *per cents.* the monthly sixpences, medals, &c. to nearly L.70,000 *per annum*, and the $\frac{2}{8}$ of 5 *per cent.* on the net proceeds of prizes to about L.40,000; making a net annual income of about L.130,000.

Scale of Allowances.

The annual allowances made to pensioners were regulated according to the following scale:

Total blindness, . : .	L.20	0	0
Loss of sight of one eye, the other impaired, according to the degree of blindness, . . .	L.8 to L.18	0	0
Loss of sight of one eye; the other not impaired, ...	6	0	0
Loss of arm, taken out of the socket, each	20	0	0
Loss of arm above the elbow, each	16	0	0
Loss of arm below the elbow, each	14	0	0
Loss of leg above the knee, each	14	0	0
Loss of leg below the knee, each	12	0	0
Double rupture, . .	12	0	0
Single ditto, retainable by a truss,	4	0	0
Single rupture, not retainable, or very bad, according to the nature of the injury, from .	L. 6 to L.10	0	0
Loss of thumb, or fore finger, close to the hand, . .	6	0	0
Loss of thumb, or fore finger, first joint remaining, . . .	4	0	0

In all cases of wounds, fractures, &c. for which no positive scale could be affixed, an allowance was made from the examining surgeon's report of the injury sustained, and a pension was granted for life, or term of years, according to circumstances.

When the wound or hurt was not thought of sufficient consequence to entitle the party to a pension, a sum of money was given as a full compensation.

Every man, at time of entry on the list, was paid the amount of half a year's pension, as present relief, which money was not deducted from growing pension.

Since the conclusion of the late war, the funds of the chest of Greenwich have been amalgamated with those of Greenwich Hospital, both of which are now under one and the same management.

Greenwich Hospital.

The establishment of Greenwich Hospital embraced more extensive objects. The first idea of this noble institution, the glory and ornament of this kingdom, has been ascribed, with every appearance of justice, to Mary, the consort of William III. Being desirous that our gallant seamen, worn down by age or infirmities, as well as suffering from wounds, should not be left destitute, she made a grant, jointly with King William, of the Palace of Greenwich, and certain lands adjoining, to be appropriated to this purpose, in order, as stated in the King's commission, to "the making some competent provision that seamen, who, by age, wounds, or other accidents, shall become disabled for further service at sea, and shall not be in a condition to maintain themselves comfortably, may not fall under hardships and miseries, but may be supported at the public charge; and that the children of such disabled seamen, and also the widows and children of such seamen as shall happen to be slain in sea service, may, in some reasonable manner, be provided for, and educated." In 1695 the committee appointed to examine and report on the premises, recommended an additional wing to King Charles's building, which being approved by the King, Sir Christopher Wren undertook the conduct of the new erections without any pay or reward. Since that time various additions and improvements have been made to this magnificent pile of building, which was completed very nearly as it now appears, in the year 1778.

The King granted L.2000 a-year towards the carrying on, perfecting, and endowing this hospital. The great Officers of State and wealthy individuals also subscribed liberally to the undertaking. It was at the same time enacted by Parliament, that a deduction of sixpence *per* man *per* month should be made out of the wages of all mariners for the use of the hospital; and power was given to the Lord High Admiral to appoint commissioners for receiving the said duty, whose office is situated on Tower Hill. In 1699 his Majesty contributed the sum of L. 19,500, being fines laid by the House of Lords on certain merchants convicted of smuggling. In 1705 Queen Anne assigned to the use of the hospital the effects of Kid the pirate, amounting to upwards of L. 6000. In 1707 Robert Osboldiston, Esq. devised by will half of his estate, which was valued at L. 20,000. In the same year Anthony Bowyer gave the reversion of a considerable estate for the use of the hospital.

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By several statutes, the forfeited and unclaimed shares of prize-money were given to the hospital, and various grants, from time to time, continued to be made by Parliament. But the most substantial grant was that made by the Commons of the rents and profits of the forfeited estates of the Earl of Derwentwater, amounting at that time to about L. 6000 a-year, and at present to the gross rental of L. 60,000, of which, after payment of all expences for improvements, repairs, collections, and incumbrances, the annual receipt may be estimated from L. 30,000 to L. 40,000.

Permanent Revenues.

At present the permanent revenues of the hospital consist of the following heads:

1. Sixpence *per* man *per* month for all seamen and marines belonging to his Majesty's naval service, and sixpence which was formerly paid to the chest at Chatham.

2. The same from all seamen employed in the merchants' service.

3. The duties arising from the North and South Foreland light-houses.

4. The rents and profits of the Derwentwater estates, including the lead mines.

5. Rents of the market of Greenwich, and of certain houses there and in London.

6. Interest of money invested in the public funds.

7. Forfeited and unclaimed shares of prize-money.

8. Fines for various offences.

It is evident that the funds of the establishment must vary considerably in times of war and peace; being lowest in the latter period, when the demands are heaviest upon it, especially for a certain number of years after the closing of a war.

The rental of the estates belonging to the hospital in the counties of Northumberland, Cumberland, and Durham, have risen from L. 23,000 in 1805, to L. 43,000 in 1816. The present gross rental of these estates and the lead mines, as above stated, amounts to about L. 60,000. The merchant seamen's sixpences amount to about L. 20,000 a-year; the naval seamen and marines to L. 15,000; the North and South Foreland lights to L. 7000; the interest of funded property to L. 50,000, making, with other contingencies, an annual revenue of about L. 150,000; the whole of which is expended on the household establishment, the clothing, maintenance, and allowances to pensioners and other attendants, repairs, taxes, and contingencies.

During the war, and for a few years after the war, the funds of the hospital were adequate to the payment of the out-pensioners, which, taken at 35,000, the greatest number they ever reached, and allowing to each, on an average, L. 11 a-year, must have amounted to the sum of L. 385,000. Their numbers may now have decreased to 30,000, and the amount of their pensions to L. 330,000, to be voted by Parliament; the funds of the hospital no longer affording a surplus beyond its own support, from which only, by law, the out-pensioners had any claim.

Hospital Establishment.

The establishment of this noble institution consists of a governor, who is a flag-officer in the navy, lieutenant-governor, four captains, eight lieutenants, all resident within the hospital. A treasurer, auditor, paymaster of pensions, secretary, clerk of the check, two chaplains, two physicians, three surgeons, two dispensers, steward, clerk of the works, and several clerks. The number of in-pensioners is about 3000, and the number of nurses 180, all of whom must be the widows of naval seamen, and under the age of 45 years at the time of admission.

Pensioned Officers on Greenwich Hospital.

Under the naval administration of Earl Grey, the following officers were added to the out-pensions of Greenwich Hospital, to be selected by the Admiralty according to their respective claims on the service:

		Per Year.
10	Post-Captains, at - -	L. 80
15	Commanders, at - -	60
50	Lieutenants, at - -	50

in addition to their half-pay.

Out-Pensioned Seamen.

The out-pensions to seamen were first established in 1763, by act of 3d Geo. III. ch. 16. in consequence of which 1400 out-pensioners were appointed, at L. 7 *per annum* each, after undergoing an examination at the Admiralty as to their claims.

At the close of the long revolutionary war, the applications became so numerous, and the claims of the seamen who had been wounded, or worn out in the service, so strongly grounded in humanity and justice, that it became necessary to adopt a scale of pensions, and to establish certain rules and regulations, by which seamen of his Majesty's fleet and royal marines should be remunerated for wounds or hurts, debility, and length of service. The following are the regulations:

For Wounds, Hurts, or Debility.

Every seaman, landman, boy, or royal marine, wounded or hurt in his Majesty's service, is to receive a sum of money from the *Chest of Chatham* in the nature of *smart money*, as heretofore; and also be entitled to a pension proportioned to his wounds or hurts, of not less than sixpence a day, and not more than one shilling and sixpence a day. For sickness or debility, after seven years' service (and under special circumstances before that period), of not less than fivepence a day, nor more than tenpence, according as he may appear capable of assisting himself. Beyond fourteen, and less than twenty-one years' service, not less than eightpence, nor more than one shilling and threepence. After twenty-one years' service, one shilling and sixpence a day.

For Length of Service.

Every able seaman, discharged on the reduction of the fleet, who has served faithfully fourteen years, and less than twenty-one, is entitled to a pension of one halfpenny a day for every year of such service. Twenty-one years' service entitles him to a free discharge, and a pension of one shilling a day; and if he may choose to continue in the service, one halfpenny a day in addition for every additional year of service.

Ordinary seamen and landmen, entitled to four-fifths and three-fifths of able seamen's pensions. The privates of royal marines are considered as ordinary

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Fig. 4.

Plan of the Stern

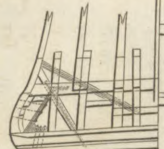
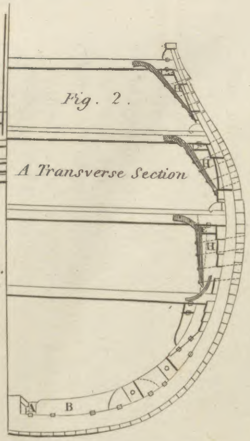


Fig. 2.

A Transverse Section



References

A.A. Lumber strake and additional Keelson forming abutments for the lower part of diagonal frame.
B.B. Timbers of the diagonal frame.
C. Longitudinal pieces to Ditto.
D. Trusses to .... Ditto.
E. Internal hoop or Gundeck shelf piece forming abutment for the upper part of the diagonal frame
F. Abutment pieces for Trusses between ports.
G. Trusses
H.H. Chocks under Shelf piece for Iron Knees.

Fig. 3.

Plan of Iron Knee.

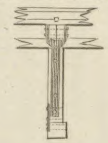
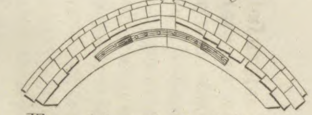


Fig. 6.



Plan of Breasthooks & Crutches.

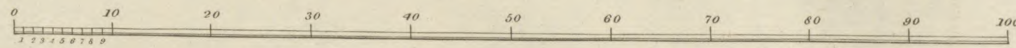


Fig. 1.

A Longitudinal Section.

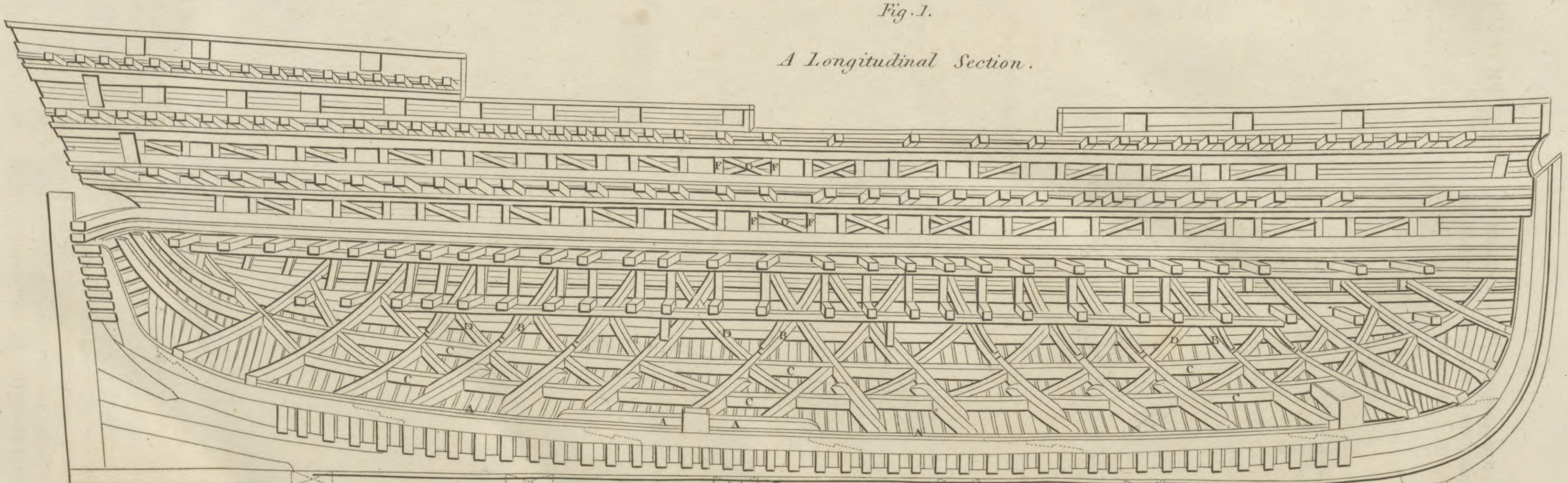
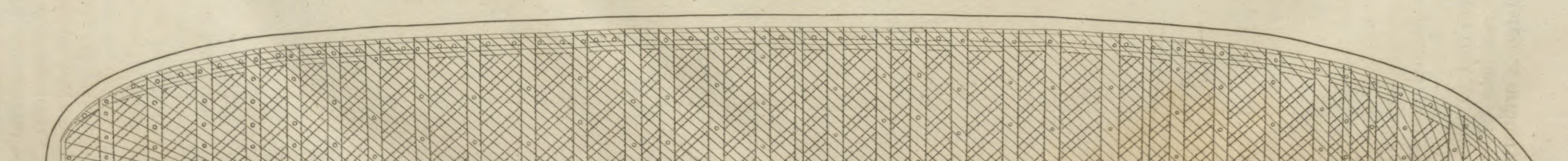


Fig. 5.

Plan of the Gun & Upper Decks



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Navy || Necker.

seamen. The principal petty officers, in addition to the above rates of pension, are entitled to one halfpenny a day for the number of years' service; the inferior petty officers to one farthing.

All the above mentioned pensions may be forfeited by misconduct, by desertion, and by sentence of a Court-Martial. Also, by neglecting, or omitting, to attend at such port, or place, and at such time as shall, in time of war, or in prospect of a war, be appointed for the assembling of the pensioners, by the Lords Commissioners of the Admiralty.

To this noble institution is appended an asylum, for the maintenance and education of the children of officers and seamen of his Majesty's naval service.

Naval Asylum.

The *Naval Asylum* was originally instituted by the Patriotic Fund and private subscriptions, and afterwards established at Greenwich, by warrant under the King's sign-manual, dated January 1818, appointing the Lords Commissioners of the Admiralty to be commissioners and governors, who, with twenty-four directors, were to superintend and manage the same. The object was, the maintenance and education of a certain number of orphans and other children of the non-commissioned officers, seamen, and marines of the royal navy. As it was manifest, however, that this establishment, so contiguous to the hospital of Greenwich, could be managed without inconvenience by the commissioners and directors of that hospital, under a more effective and economical system, his Majesty was pleased, by his warrant of January 1821, to annul the former warrant, and to vest the superintendence and internal management of the said asylum in the commissioners and governors of Greenwich Hospital.

The two schools of Greenwich Hospital, and the Naval Asylum, and the funds thereof, are now therefore incorporated. The internal management is confided to the Board of Directors, and one of the captains of the hospital is intrusted with the general superintendence. A chaplain, and proper schoolmasters, schoolmistresses, matron, with inferior assistants, male and female, with moderate salaries, reside in the building. The number of children maintained and educated in the Institution are:

In the Boys' Upper School, - -	200
Ditto, Lower School, - -	600
Girls, - - - - -	200
In the whole,	1000

To the upper school no boys are admitted but the sons of seamen and marines, slain, drowned, or dead; of pensioners in the hospital; of seamen disabled, past their labour, or otherwise objects of charity; of officers in the navy and marines, on the production of a required certificate of poverty. The age of admission from eleven to twelve: the continuance in the school three years, when they are bound apprentices to the merchant service. Presentations by the directors in rotation.

The boys and girls of the lower school are the children of seamen and marines of the naval service, admitted by the Board of Directors, giving a preference to orphans. The age of admission from nine to twelve years inclusive; but none to be retained beyond the age of fourteen. The boys to be sent into the navy, or merchant service, or put apprentices to some trade. The girls, at the age of fourteen, to be apprenticed to trades, or sent to service.

Thus are all the classes of officers, seamen, and marines, who have faithfully served in the navy, provided for by the state; and the children of such as may be in indigent circumstances receive an education at the public expence, suited to their condition in life.

The total expence of the whole navy, including every branch of the service, civil and military, for one whole year, in the middle of the late war, may be estimated at about - L. 18,000,000

In the year 1822, according to the estimates laid before Parliament, at about 5,000,000

NECKER (James), a well known statesman and financier of France. He was born, 30th September 1732, at Geneva, of a respectable family, originally from the north of Germany. At the age of fifteen he quitted Geneva, and proceeded to Paris with a view to push his fortune in that city. He entered first into the banking-house of Vernet, and afterwards into that of Thelluson, of which he became the cashier, and at length a partner. On the death of Thelluson, he established a bank on his own account, by which he accumulated a very large fortune. After twenty years of unremitting attention to business, he married a Protestant lady of respectable family, but in reduced circumstances, the patrimonial estate having been lost in consequence of the revocation of the edict of Nantz. With this lady he appears to have enjoyed the highest degree of domestic happiness. A short time after his marriage, he was named minister of the republic of Geneva at Paris; and in accepting of this employment, he refused the emoluments which were attached to it,—a degree of forbearance not very usual in public men, but in which he resolutely persisted during the whole course of his political life. Two works which he published, namely, *A Eulogium on Colbert*, and a treatise *On the Legislation and Trade of Corn*, had greatly spread the reputation of his political talents; and he had fortunately succeeded in adjusting some differences between the East India Company and the Crown, in such a manner as to receive the approbation of both parties,—a circumstance which added to the weight of his character.

About this time the disorder in the state of the French finances had become so alarming, that it was found necessary to break through the routine of official promotion, and to choose able men for

Necker.

the public service wherever they could be found. These inducements so far outweighed the objections to M. Necker, as a foreigner and a Protestant, that, after some private conversations with M. Maurepas, he was, in 1776, appointed Director of the Royal Treasury, and in the following year, Director-general of the Finances. The great object of M. Necker was to introduce order and economy in the public management. With this view, he found himself compelled either to suppress useless offices, or to diminish emoluments; and his retrenchments drew on him the enmity of all those who suffered by his economical reforms. A party was formed against him, chiefly composed of rapacious courtiers; and though the repeal of several oppressive imposts had conciliated the general good-will of the people, he was daily the object of malicious libels. His severe measures of economy had also excited the dislike of the minister M. Maurepas; though others ascribe his hostility to a different cause; namely, to his disappointment at not finding in Necker that subserviency which he expected from a person of his comparatively obscure origin, and a Protestant. Whatever was the reason, the minister was among the number of his enemies, and he is charged by his daughter, Madame de Stael, with secretly instigating those libellous attacks of which M. Necker was the object. To enable him, according to Madame de Stael, the better to struggle with his opponents, he requested some signal mark of royal favour, such as a seat in the Council, which was granted. This demand on the part of Necker gave rise to new and acrimonious discussions; in the course of which he tendered his resignation, after he had been in office five years. Others give a different account of this transaction. Under the influence, it is said, of that passion for popular applause, which was the torment of his life, he published, in 1781, the well known piece on the state of the Finances entitled *Le Compte Rendu au Roi*, of which an immense number of copies were sold. Elated by this success, he made his demand for a seat in the Council, but was objected to on the ground of his religion. Being persuaded that this scruple would be abandoned, he persisted, and offered his resignation, which was accepted, and he became in this manner, as is alleged, the dupe of his presumption.

The enemies of Necker reproached him with indulging, during his short administration, his passion for popularity at the expence of the public interest. The great point which he laboured to establish in his *Compte Rendu* was, that there was no deficit in the public revenue, and that there was no necessity for additional taxes. In lieu of new impositions, he is charged with supplying the public necessities by the expedient of large loans,—postponing, in this manner, the evil day, but accumulating on posterity a progressive load of debt, which, sooner or later, must be provided for by adequate taxes,—and all this to procure a temporary popularity at the expence of his rivals. Notwithstanding these objections, he had numerous partizans, especially among the men of letters, who regarded his elevation to power as the triumph of philosophy and liberal principles over aristocratical prejudice.

Necker.

After his resignation, he retired to Switzerland, where he purchased the barony of Copet. In 1784, he published an able work, further illustrating his financial policy, entitled *De l'Administration des Finances*. This work, of which 80,000 copies were speedily sold, served to support the reputation of his plans, and also to keep together his adherents, whose numbers formed a counterpoise to the influence of his enemies at court.

In 1787, M. de Calonne convoked the Assembly of the Notables, and in his opening speech to that body, he impeached the accuracy of the statements contained in the *Compte Rendu*. It was not to be supposed that M. Necker would quietly submit to this charge. He sent a memorial on the subject to the king, with various other papers, for the purpose of proving the correctness of his calculations. His majesty having read these documents, requested that they might not be published; a proposition which by no means suited the views of M. Necker. His statements were accordingly printed, on which he was exiled, by a *lettre de cachet*, forty leagues from Paris.

M. de Calonne did not, however, remain long in power; and the Archbishop of Toulouse, by whom he was succeeded, was also obliged to resign, and to make way for M. Necker, the favourite of the people, who was reinstated in his former post in August 1788. A new and remarkable era was now about to open in the history both of France and of the world. The writings of the French philosophers and men of letters had gradually given currency to notions of constitutional freedom. The people could no longer endure, like their forefathers, the bondage of feudal privileges, by which the few acquired the power of oppressing the many. They had become jealous and discontented, and were deeply irritated at the insolence and oppression of the aristocratical body; and with those indignant feelings were mingled, in the minds of the popular leaders, the brilliant visions of speculative reform. But so long as the people wanted a legitimate organ through which their voice could be heard, it was clear that whatever might be their feelings, they could make little impression on the measures of the state. What was wanting in this respect was now about to be supplied; and the popular voice, hitherto so little considered, was, through the representative body, to become the pre-eminent influence in the government. At this period the French Government was assailed by a complication of difficulties, the chief of which was the impracticability of raising the necessary supplies, and the danger of an immediate bankruptcy. A great scarcity also prevailed at Paris, which rendered the populace unusually discontented and tumultuous. In this emergency various expedients were suggested; and the convocation of the States General, which had been long talked of, was advised by M. Necker as likely to give general satisfaction to the people. In assenting to this proposition, it was the plan of the court, that the different orders of the clergy, nobility, and commons, should vote in separate chambers, in or-

der that the deputies of the commons might be controlled by the other two bodies. But the popular leaders were by far too penetrating to allow their influence to be annihilated by this device. They determined, from the beginning, that the three orders should sit and vote together; and, as is well known, after various fruitless efforts to bring about this union, the commons resolved to form themselves into an Assembly for the dispatch of business, without regard to the other two chambers. This decisive step proved effectual, and the three chambers at length all met and voted in one house, by which the whole power was thrown into the hands of the commons.

During these transactions, Louis and his advisers pursued a weak and vacillating policy. They saw, when it was too late, the error they committed, or supposed themselves to have committed, in putting into the hands of the people the powerful weapon of a representative body. But in place of yielding to the necessity of circumstances, and conciliating this new power, which they could now no longer resist, by conceding with a good grace every just demand of constitutional right, they endeavoured to recover the ground which they had for ever lost; vainly struggling against the power of the commons, and meditating even the most violent measures for the recovery of their authority. It was in pursuance of these views that troops were drawn from the most distant parts and encamped around Paris;—a measure, the only construction that could be put upon which was, that it was intended to overawe the deliberations of the Assembly, or, perhaps, to dissolve it at once at the point of the bayonet. These violent courses M. Necker opposed, and he was accordingly dismissed on the 11th July 1789, and ordered to quit the kingdom in twenty-four hours. This order he obeyed with equal secrecy and dispatch, and had arrived at Brussels before it was generally known in Paris that he was out of office.

It is impossible to describe the consternation which prevailed in the capital when the dismissal and exile of this favourite minister was made known. The person who first communicated the intelligence was considered as a madman, and with difficulty escaped some harsh treatment; and the event was no sooner confirmed, than all the shops and places of amusement were shut up, and his bust, with that of the Duke of Orleans, was paraded through the streets, dressed in mourning. These proceedings were interrupted by a German regiment; the busts were broken in pieces; and in the course of the tumult one man lost his life, while others were wounded. Fresh troops arriving, a serious conflict ensued; and an old man being cut down in the Thuilleries by an officer of distinction, the populace were enraged to the highest pitch, and being joined by the French Guards, who deserted their officers, they at last succeeded in overpowering the Germans. New outrages and tumults succeeded; the Bastille was stormed; and the capital became the scene of bloody massacres, while the people's minds were at the same time filled with dismay at the near approach of foreign troops, from whom they apprehended nothing less than the sack of the city. In the midst of these alarms, they beseeched the Assembly to intercede with the king for the recal of their favourite minister. The necessity of complying with this demand was at length seen by the king, and a letter was written to M. Necker, requesting him to return.

M. Necker was at Basle when he received this letter, with the request contained in which he resolved immediately to comply. His progress to Paris was one continued triumph. He was cheered as he passed through the different towns by the acclamations of multitudes, who hailed him as their deliverer. This popularity, however, was not of long duration. Alarmed by the excesses which had already taken place, M. Necker became desirous to support the authority of the sovereign; and, without conciliating the confidence of the king's friends, he lost that of the popular party. By the Royalists he was always hated; he now became an object of suspicion to the more violent patriots, and was reproached as an aristocrat. Seeing his popularity on the decline, he resolved to retire, and he accordingly wrote a letter to the Assembly, pleading the necessity of repose for the restoration of his health. No notice was taken of this letter; and his personal safety being now in danger from the violence of the people, he quitted Paris, in a private manner, in the month of December 1790.

After the loss of power and popularity, M. Necker seems to have sunk into the greatest dejection. "I could have wished," says Mr Gibbon, who passed some days with him about this period, "to have exhibited him as a warning to any aspiring youth possessed with the demon of ambition. With all the means of private happiness in his power, he is the most miserable of human beings; the past, the present, and the future, are equally odious to him. When I suggested some domestic amusements, he answered with a deep tone of despair, 'In the state in which I am I can feel nothing but the blast which has overthrown me.'"

His mind was soon diverted from the disappointments of ambition by domestic griefs of a more poignant nature; his wife, to whom he was deeply attached, dying after a long illness, in which he attended her with great affection. He had now recourse to writing to divert his melancholy, and several works, which he published, were the fruits of his labours. He died at Copet, on the 9th April 1804, after a short but painful illness. His public character is, of course, differently estimated, according to the political views of parties. In his private and domestic relations he was amiable and affectionate, and appears to have been greatly beloved. His writings, besides those already mentioned, are the following:

An Answer to the Memorial of the Abbe Marellet, on the East India Company, 1769. *Memorials on the Provincial Administrations*, 1781. *Answer to the Speech pronounced by M. de Calonne to the Assembly of Notables*, 1787. *New Explanations on the Compte Rendu*, 1788. *Of the Importance of Religious Opinions*, 1788. *Observations on the Introduction to the Red Book*, 1790. *On the Administration of M. Necker, by Himself*, 1791. *On the Executive Power in Great States*, 1791. *On the*

Nepaul || Netherlands.

French Revolution, 1796. *Course of Religious Morality*, 1800. *Last Views of Politics and Finance.* See *Dictionnaire Universelle*, Article NECKER.—*Biographie Universelle*, Article NECKER.—*Mémoires sur la Vie Privée de mon Pere*, par Madame la Baronne de Stael-Holstein, *suivis des Melanges de M. Necker.* (o.)

NEPAUL, a long but narrow kingdom of Northern Hindostan, bounded on the north by the great range of Himmalaya mountains, on the south by the provinces of Bahar, Oude, and Delhi, on the east it is limited by Bootan, and the territory of the rajah of Si Kim; and previous to the late war with the British, their conquests extended to the banks of the Suttelege, the eastern river of the Punjab. The kingdom was then divided into the following provinces, viz. Gorcah, Kyrat, Morung, Muckwany, Mockwanpore, Lamjung, 24 Rajahs, Kemaon, and Almora. The valley of Nepaul proper, from whence the kingdom takes its name, is nearly of an oval figure; its greatest length from north to south being 12 miles, by 9 in the greatest breadth. On the north and south it is bounded by lofty mountains, but is more open to the east and west. This small track is very populous, and, besides the capital Catamandoo, is filled with villages. This valley, although situated between the 27th and 28th degrees of N. lat. is so elevated, that it enjoys an European climate, and the mountains, covered with snow, are in sight the whole year round. The soil is productive, and, in some places, yields two crops in the year. The mountains of Nepaul contain mines of copper and iron; and, although commerce is not encouraged, it sends to Bengal ivory, wax, honey, timber, bastard cinnamon, cardamums, walnuts, &c.; and takes in return, muslins and silks of Bengal, carpets, spices, tobacco, and European goods.

The government is despotic, and the rajah is considered as the proprietor of the soil. The natives are in general a hardy and courageous race; and during the late war gave the British much annoyance. This, however, partly arose from the seat of war being in a mountainous and cold country, to which the British sepoys had not been accustomed. The prevailing religion is the Hindoo, but many of the inhabitants are supposed to be descendants of Tartars, and reckoned impure. The tribe called Newars admit of poliandry, or rather the women are at liberty to divorce their husbands, and take others as often as they choose. The Brahmins of Nepaul are very numerous, and deeply skilled in Sanscrit lore. One of the libraries is said to contain 15,000 volumes in that language. There are five vernacular languages, but the Hindostany is pretty generally understood.—*Edinburgh Gazetteer, or Geographical Dictionary*, Vol. IV. For an account of the late war, see the Article INDIA, in this *Supplement*.

NETHERLANDS, a kingdom newly erected in Europe, in consequence of the fall of the French empire. It is composed of the ancient republic of the United Netherlands, usually denominated Holland, of the Austrian Netherlands, commonly called the Belgian Provinces, of the Bishoprick of Liege, and of the provinces of Huissen and Zevenaar, formerly belonging to Prussia. It is a compact dominion, bounded on the west by the German Ocean, on the north by the German Ocean and the Zuyder Sea, on the east by the duchy of Oldenburg, and by the Prussian provinces of Westphalia and the Lower Rhine, and on the south by France.

Netherlands.

The erection of the kingdom of Holland by Bonaparte, and its subsequent union with France, were attended with alterations in the names and the divisions of the Provinces, or, as they were previously called, the States; and similar divisions were made in the Austrian provinces, which produced much confusion; but since the establishment of the new kingdom, such divisions have been adopted as best reconcile the ancient denominations with the novel political condition of the country.

The recent divisions of the kingdom are into the following provinces, which are arranged according to their ranks.

Divisions.

Provinces.	Capitals.	Population of the Capitals.
1 North Brabant	Herzogenbusch	13,340
2 South Brabant	Brussels -	72,280
3 Limbourg -	Limbourg -	8,200
4 Guelderland -	Nimmeguen	12,780
5 Liege - -	Liege -	45,300
6 East Flanders -	Ghent -	44,000
7 West Flanders -	Bruges -	32,990
8 Hainault -	Mons -	18,400
9 Holland (North and South)	Amsterdam	193,180
10 Zealand -	Middleburg	20,800
11 Namur -	Namur -	15,100
12 Antwerp -	Antwerp -	62,000
13 Utrecht -	Utrecht -	33,400
14 Friesland -	Leuwarden	16,500
15 Overyssel -	Deventer -	10,100
16 Gröningen -	Gröningen -	24,600
17 Drenthe -	Assen -	1,100
18 Luxembourg -	Luxembourg	10,250

The other most considerable cities and their population are the following:

Alost, 10,920. Cortryk, 13,570. Delft, 13,850. Dornick, 21,300. Dort, 19,500. Gouda, 11,370. Haarlem, 20,100. Hague, 42,700. Leyden, 30,680. Lokeren, 11,940. Louvain, 18,580. Maestricht, 17,960. Mechlin, 16,090. Ostend, 10,500. Rotterdam, 33,800. St Nicholas, 10,980. Verviers, 10,070. Ypres, 15,150, and Zwoll, 13,060.

Although the duchy of Luxembourg is included in the kingdom of the Netherlands, in the view we are taking of it, yet it is in reality a part of Germany, and its capital, one of the strongest fortresses in Europe, is garrisoned by the confederates. The King of the Netherlands has, indeed, the nomination of the governor of the castle, but the consent of the Allies is requisite, before he can enter upon the command. Thus, the annexation of Luxembourg to the kingdom of the Netherlands resembles that of the duchies of Holstein and Lauenburg to the kingdom of Denmark.

The surface of this kingdom, according to the

Netherlands. most accurate calculations, amounts, in the northern provinces, to 16,588 square English miles; from which must be deducted for the Zuyder Sea, the lakes, rivers, and canals, 5205 square miles; leaving 11,383 miles. The whole extent will then be thus:

Extent.

In the nine northern provinces,	11,383
In the eight southern provinces,	11,141
In the duchy of Luxembourg,	2346
	24,870 square

miles, or 15,916,800 English acres.

Population. According to the census of the year 1816, the population was as follows:

The northern provinces,	2,016,159
The southern provinces,	3,249,841
The duchy of Luxembourg,	225,945
	5,491,945, being

somewhat more than one human being to every three acres of land; a density of population far exceeding that of any other country of Europe, with the exception of the small and highly productive duchy of Lucca in Italy. The difference in the density of population in the different provinces is very great. The most thickly peopled of them, East Flanders, contains 560 inhabitants to the square mile, or nearly one to each acre; whilst Drenthe contains only 59 to the square mile, or less than one to every ten acres. The average population of the provinces of the United Netherlands is 180 to the square mile, or about one person to three acres and a half; of the provinces of the Austrian Netherlands 296 to the square mile, or one person to two acres and a quarter; and of the duchy of Luxembourg, 66 to the square mile, or nearly one to ten acres. *

Face of the Country. Almost the whole of this united kingdom possesses a flat surface, with scarcely a hill on the greater part of it. The level of most of the lands on the northern part is below that of the sea that bounds it, when the tide is at the highest, and is only protected from inundations by such powerful embankments called dikes, as demonstrate the patient perseverance and the wealth of the proprietors. In the southern part, the Belgian provinces are mostly level, though sufficiently above the sea not to need the protection of embankments. In the parts bordering on towards France, especially in the provinces of Liege, Namur, and Luxembourg, including a portion of the ancient forest of Ardennes, the surface is more irregular, in some parts undulating, in others hilly, approaching almost to mountainous. There are no forests, and but few trees in the northern parts, except willows, which are abundantly planted on the sides of the canals and embankments. In the ancient Belgic provinces, trees are more frequent, both on the borders of the fields and around the villages, but there are few woods except in Liege and Luxembourg. From this description, it will be readily perceived, that no picturesque scenery is displayed; but the cleanliness and appearance of substantial comforts in all the villages and thickly planted farms, gives to the traveller pleasing sensations, and evince most powerfully the wonders which industry and perseverance can achieve.

Rivers, Canals, and Lakes. No part of Europe enjoys such advantages for dispensing abroad its more bulky productions as the kingdom of the Netherlands. Its navigable rivers, which are connected together by numerous canals, that serve the purposes both of draining and conveyance, intersect the whole of the northern and the greater part of the southern division of the kingdom. The principal of these rivers, the Rhine, is divided into two branches; the southernmost of these takes the name of the Waal, and, after receiving the water of the Merwe, assumes the name Maas, and enters the German Ocean. The northernmost branch of the Rhine is divided into two streams, one, called the Yssel, runs to the Zuyder Sea, the other, retaining its original name, after receiving the waters of the Lech and the Vecht, disappears in the sands. The Meuse, the most important river to the Belgic provinces, is navigable through the whole territory, and is the means of conveying from Liege the stone for building, which abounds in that vicinity, and of which the provinces on the coast are wholly destitute. The Sheldt, a river of a short course, but of excellent navigation, divides itself into two branches, called the East and West Sheldt, before it enters the German Ocean. The Lys, the Dender, the Dyle, the Sambre, the Lesse, the Nethe, and many others of smaller magnitude, are tributary streams to the Meuse or to the Sheldt. The Moselle, though it forms the boundary of this kingdom on its south-eastern side, and is highly beneficial to its commerce, passes through no part of it. There are few lakes in this country. The principal is that of Haarlem, extending over about 16,000 English acres, which is connected with two smaller ones, the Dollart and the Biesbosch. The interior communication by water is so great, that it employs 5700 barges of different burden, and upwards of 15,000 boats.

Climate. The climate of this kingdom, from its vicinity to the sea, and from the abundance of its rivers and canals, is peculiarly foggy. In summer the heat is excessive, but highly favourable to vegetation. In winter the frosts are usually very severe, and in some years, the rivers are so frozen as to bear the conveyance of cannon and heavy loaded waggons. Only the most scrupulous attention to cleanliness can, in any degree, protect the inhabitants from the deleterious effects of their moist atmosphere, and with all the care that is exercised, they are much subject to fevers.

Government. The constitution of this country is a limited monarchy, hereditary in the House of Orange-Nassau, to which the females may succeed, in case no male heir is left by the last monarch. The king can hold

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* See *Hofalmanak voor het Schrikkeljahr* 1816 *ins Gravenhage;* also *Staat-on aardrykkundige Beschrivung von het Koningryk der Neederlanden of de XVII neederlandische Provinzien, benever het Groot-Hertogdom Luxemburg,* van N. G. van Kampen. Harlem, 1816.

Netherlands.

no foreign crown, nor remove the seat of government out of the kingdom. He is authorized to take from the treasury 2,400,000 guldens annually, for his own expenditure. He is allowed a summer and winter palace at the expence of the public, but the sum expended on them must not exceed 100,000 guldens annually. The heir-apparent bears the title of Prince of Orange, and enjoys an income of 100,000 guldens. The king's minority terminates on the completion of his eighteenth year, and whilst under that age, the government is administered by a regency consisting of the members of the royal family. The executive government is vested, but with many restrictions, arising from the independent and varied constitution of the several states, in the king, who is commander of the army and navy, has the power of dispensing pardons, and whose consent is necessary both to the laws passed in the Provincial and in the General Assemblies of the States.

Each state has its assemblies, which are convoked annually, or more frequently if deemed necessary, by the monarch. The members are in two classes, viz. 1*st*, the nobles and knights; and, 2*d*, the citizens, who elect members to fill the vacancies that occur in their body. With the assembly of the citizens, or burghers, rests the local administration, and, jointly with the nobles, the power of enacting provincial laws. They appoint committees from their body to attend to the administration of justice, of the revenues, and the expenditure; which committees meet as well during the prorogation as the session of the states, and are the medium of intercourse between their several provinces, the monarch, and states-general. The levying taxes for provincial purposes is executed by this body, who carefully guard against the imposts they levy being made to fall heavier on articles produced in the other states than on those produced within their own; as, without such precaution, the consent of the king to the enactment would be withheld. A commissary, or administrator, nominated by the monarch, is joined to each assembly of the provincial states, and has considerable powers for superintending the execution of the laws. The police is managed jointly by this officer and the provincial states, and is generally conducted with judgment, economy, and great attention to the liberty of the subject.

The supreme legislature, or States-General, meets either at Brussels or the Hague. It is divided into two chambers. The upper house consists of not less than forty, nor more than sixty members, who are nominated by the king, and hold their seats for life, but do not transmit them to their heirs. The lower house consists of one hundred and ten members, who are nominated by the provincial assemblies of the different states. The members of these two bodies are chosen both from the Dutch and Belgian provinces; and, as in the latter, the French language is used by all but the peasantry, their debates are conducted in either the Dutch or the French tongues, according to the part of the kingdom of which the speaker is a native.

Judicial Administration.

The judicial administration is in an imperfect state at present, owing to the different provinces having different systems of law. The legislative body has been sedulously employed in forming a general code which shall embrace the whole kingdom, but, from the various usages and rights of ancient establishment, which they wish to protect, it has been found to be attended with almost insurmountable difficulties.

In the meantime, the securities for the personal liberty of the subject are of more practical efficacy than are to be found in any other country of Europe, except in Great Britain. No one can be arrested without a previous communication to the judge, and the prisoner must be made acquainted with the charge against him within three days after his commitment. No one can be withdrawn from the judge of one district to be tried before that of another, without his own appeal, or at least his consent. Every judgment against an offender must specify the precise article in the law under which the punishment is awarded. In all civil causes, the reasons upon which the decision of the court is founded must appear upon the face of the judgment. Each province has its own courts, both for criminal and civil cases; besides which, there is a supreme court for the whole kingdom, denominated the *Superior Council of the Netherlands*. Equal protection is extended to every description of religious worship, and the professors of all the various sects are equally admissible to every civil, military, and judicial post, and may enjoy like civic and political dignities and privileges.

Religion.

Although equal protection is granted to all religious sects, yet the establishments of the two predominant confessions, whose opinions prevail in the northern and southern parts of the kingdom, give to the Catholic and the Calvinistic parties a considerable degree of preponderance. The sovereign is of the reformed or Calvinistic profession, as are the greater part of the inhabitants of the northern provinces, who adhere to the catechism of Heidelburg, and the confession of Dort, and are regulated by parochial church councils, classes, and synods. In Utrecht is a Catholic archbishop, and in Haarlem a bishop. The religion of almost the whole inhabitants of the southern provinces is the Catholic, to which they are most rigidly attached. They have one archbishop, four bishops, and more than three thousand priests; although, since these provinces were formed into one of the French departments, their number and emoluments have considerably diminished. The universal toleration which has long prevailed in the northern part of this kingdom has familiarized it to the most bigotted members of the established church; but, in the southern parts, where it has only been introduced since the dissolution of the French empire, it has been most strenuously opposed, especially by the ecclesiastics, and its establishment has caused in some places tumults, and in others great dissatisfaction, which is by no means yet removed. The practical enjoyment of religious toleration in the Belgian provinces is indeed even now rather to be wished than expected.

Origin and Character of the People.

The inhabitants of this kingdom are descended from three different races, and even now discover those differences which they have derived from their origin. The people of Holland, Zealand, Utrecht, Guelderland, Overyssel, and Drenthe, are of Batavian origin, probably descended from the ancient

Netherlands. Katti, and speak a flat Deutsche, or Low German language. They are more prudent than active, their minds more exact than comprehensive. They usually reason slowly, but accurately. They are economical, prudent, and cleanly, but too eager for gain, and, by the prospect of it, can alone be stimulated to deeds of daring or adventure. The people of Friesland, Gröningen, and the islands of the ocean, and the Zuyder Sea, are descended from the Frisi. They differ from the Hollanders in their language and dress, and, unlike them, are more addicted ot agriculture, to the rearing of cattle, and to the fisheries, than to navigation and commerce. The southern provinces are inhabited by the descendants of the Walloons, a branch of the great German family, whose habits they still in a great degree retain; though they have become somewhat Frenchified, and whose language is a dialect of the German, but differing materially from that spoken either by the Hollanders, or the people of Westphalia and Lower Saxony.

Institutions for Instruction.

Few countries have, according to their extent and population, more institutions for the promotion of learning than are to be found in the Netherlands. There are six universities, viz. Leyden, Utrecht, and Gröningen, in the northern, and Louvain, Ghent, and Liege, in the southern provinces. Besides these are the atheneums of Amsterdam, Middleburg, Deventer, and Doornich, and 105 public grammar schools for classical instruction, in which is kept alive that taste for literature which formerly produced some of the best editions of the writings of antiquity. In the northern part of the kingdom, the instruction of the lower classes is amply provided for by numerous well regulated burgher schools, in which gratuitous education is extensively, almost universally, dispensed, and the new system of mutual instruction generally adopted. In the southern provinces, the education of the poor is much neglected, but the present government has pledged itself to remedy this evil, and is taking steps for that purpose.

Restrictions on the Press.

The freedom of the press in this kingdom was, at its first establishment, without restriction; but the vicinity of Brussels to France, the great number of those Frenchmen who were dissatisfied with the restoration of the ancient monarchy that took up their residence there, and the attempts made by them to spread disaffection, on the ground that religious toleration was incompatible with the rights of the Catholic Church, compelled the Government to place the smaller works which issued from the press under several restrictions. These restrictions do not extend to works containing more than four sheets, and larger works may be published without any previous licence; but the authors and publishers are amenable to the tribunals for their contents, if they are judged to be treasonable, seditious, irreligious, or immoral.

Manufactures.

In the most remote periods, the Netherlands were distinguished by their manufacturing skill and industry. Under the Romans, the inhabitants of Arras and several other Flemish cities were celebrated for the production of woollen cloths. At a later period, under the Emperor Charlemagne, a present of fine linen and of woollen cloth, sent to the Caliph of Bagdad, Harun al Raschid, was deemed to display the most curious specimens of the industry and skill of the Western World. In the instructions of that monarch (*Capitular. de villis Regum Francorum*), it appears that at Liege and other cities of the Netherlands, very extensive manufactories, both from flax and wool, existed, in the dyeing of which madder and kermes berries were used, and were forbidden to be adulterated. The ancient condition of the manufactories of the Netherlands is peculiarly interesting, because it is to them that we and the rest of Europe are indebted for the first rudiments of those arts, which have since been so widely extended in England, Scotland, France, Germany, and Holland. In the time of Charlemagne, it appears from the same collection, and from the *Historia Monasterii Salmuriensis*, that iron wares, gold and silver work, embroidery, arms, horse furniture, and various other articles, were extensively manufactured. The earliest Flemish fabrics were those of linen; and as early as the year 960, free marts were established in several of the cities, to which great numbers of merchants from foreign countries periodically resorted. The present state of the linen manufactory is by no means flourishing; but large quantities of the finer kinds from flax, of their native growth, is supplied by the inhabitants of this kingdom, and is everywhere most highly esteemed. The finest yarn and the best bleacheries are at Haarlem; the best linen is wove at Herzogenbasch, Eindoven, and some other places; but some fine linen, spun in Westphalia, is mixed with that of those places, and when bleached in Holland, is not distinguishable from it. The curious manufactory of thread lace originated in this country, and still distinguishes it. The best is that of Brussels and Mecklin. In the former city and its vicinity it once gave employment to more than 14,000 persons; and at one period the exports of goods fabricated in Flanders, from flax of their own growth, amounted to more than L. 2,000,000 Sterling. The woollen manufactories of Flanders were in a flourishing state as early as the year 980, but were most extensive from the twelfth to the sixteenth century. In the city of Louvain, in the year 1317, there were 4000 looms for weaving woollens. Brussels and Antwerp employed an equal number. Ghent was, however, the most distinguished city for its fabrics, both of wool and flax, and at that period employed 40,000 looms. When called upon to take arms, the weavers, under the banners of their trade, mustered 16,000 men. Ypres contained 4000 looms. Bruges was the storehouse and central point for the commerce of half Europe; but the situation was changed for that of Antwerp in 1478, which continued to be one of the most flourishing cities of the world till the beginning of the sixteenth century, when the tyranny and fanaticism of Philip the Second of Spain inflicted on the Flemish provinces the most distressing sufferings. The great prevalence of goods made from cotton, the improvements that have been made in machinery for spinning thread from that substance, as well as from flax and wool, and the long war, which suspended a great portion of the export trade, have had a very injurious effect on the manufactures of this kingdom; but they still exceed, both

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in the numbers of people to whom they give employment, and in the excellence of their productions, those of any other country of Europe, except the British dominions. Woollen goods are extensively produced in Verviers, Eupen, Hodimont, Leyden, and Utrecht, and in smaller quantities in many other places. Cotton articles are made principally in Brussels and Amsterdam. Silk, though on the decline, is worked at Haarlem. Leather of an excellent quality is produced at Liege and Maestricht. Tobacco and snuff are manufactured at Amsterdam and Rotterdam, in which places 24,000 persons are occupied in that trade. In Amsterdam are seventy sugar refineries, in Rotterdam eighteen, in Dort twelve, and several in Antwerp, Ghent, and Ostend. Iron goods are produced in many places; but the cutlery made at Namur, and the arms made at Liege, are peculiarly valued. The earthenware of Delft, formerly so celebrated, has been almost superseded by the English potteries. The quantity of pipes for smoking tobacco produced in this country is so great, that in the town of Gouda alone their fabrication employs more than 5000 persons. The breweries are both numerous and upon a large scale, but are inferior to the distilleries, which furnish a corn spirit, when flavoured with juniper berries, well known throughout the world by the name of Geneva or gin. The greater concerns of this kind are established at Scheidam, at Rotterdam, Amsterdam, and Weesp. That which is made at the latter place is said to have the peculiar property of preserving its qualities in the hottest climates, and is largely exported to the East and West Indies.

Agriculture.

The agriculture of the kingdom of the Netherlands, which, even in the northern portion, that was formerly the Seven United Provinces, was more the foundation of its wealth than either manufactures or navigation, deserves the most close examination, and merits more detailed accounts than our limits will allow. As this northern part is principally a country of land redeemed from the sea, it is naturally appropriated chiefly to the growth of the various grasses whose produce affords sustenance for horned cattle, and the profit of which is derived from the butter and cheese that these cattle yield. The corn land of Holland is insufficient for its own consumption, but the productions of the dairy afford ample means for purchasing the requisite quantities of grain. The cows of this district are fine cattle; and though they do not yield, on an average, so large a quantity of milk as many of our English cows, yet, from the butter and cheese they produce, it seems to be of a better quality. The answers of Mr Van de Poes to some queries of Sir John Sinclair state, that the quantity of milk from each cow averages about three quarts daily; that the annual produce of each cow is calculated by the Committee of Agriculture of the Province of South Holland at 78 pounds of butter, and 180 pounds of cheese. During the winter months the cattle are fed with hay, turnips, carrots, grains from the distilleries, linseed oil cake, and bear meal, and are confined to their stalls. In the summer months, soiling or stall-feeding is not practised, but the cattle are grazed day and night in the meadows. The bulls are used for the purposes of propagation from the age of one year and a half to two years and a half. At reaching that age, they are no longer so employed. The whole offspring, being thus derived solely from young males, are considered to be more valuable than could be obtained by a different plan. In the management of the dairies, both from the milking the cows, and through every subsequent operation, the most scrupulous attention is paid to cleanliness, and this attention is visible in all the utensils, as well as in the temperature which is maintained in the houses, and the state of neatness exhibited in the stalls, the litter, and on the bodies of the animals. The butter of Holland is made wholly of cream; the churning is commonly performed by very simple machinery, set on motion sometimes by a horse, and often by two dogs; in the progress of making, frequent washings are used, and it is preserved solely by being well salted. The butter-milk is applied to feed calves or to fatten pigs, and the skimmed milk is converted into an inferior kind of cheese.

Dairy.

Arable Husbandry.

Although the greater part of the agricultural attention of Holland is directed to dairies, and the fattening of cattle, yet, on receding from the coast, and reaching the more elevated lands towards the German frontier, the husbandry assumes the character of that of the midland counties of England; but with such variations as are adapted to the soil, climate, and habits of the people. On the banks of the Rhine in Guelderland, as well as in the province of Utrecht, the arable husbandry is judiciously conducted. The manure is preserved with great care, the ploughing well executed, and a good rotation of crops followed. On some of the lighter soils, the land, when cleaned and manured, is sowed in May with buck-wheat. This crop is harvested in August, when rye is sown on it; and after the rye is carried, which is usually done in the succeeding July, turnips are sowed. The land thus produces three crops in two years. On the stronger soils, the usual rotation is beans, wheat, clover, and oats; and, on the most tenacious of all the soils, they precede the beans by a whole year's clean fallow. In such soils the produce of four harvests exceeds those of five harvests when the fallow is omitted. During the existence of the Continental System of Buonaparte, the cultivation of tobacco, and of beets of different kind for making sugar was introduced, and extended over large surfaces; but the return of peace, by which the ports of the Continent were opened to those productions from the western world, created a competition, which the Dutch husbandmen were unable to withstand, and the cultivators of these articles have become involved in great distress.

The agriculture of the southern division of the kingdom, formerly the Austrian Netherlands, is peculiarly interesting, and conducted upon plans replete with economy, and productive of the most uniform and beneficial results. The land of Flanders was not naturally fertile; on the contrary, the quality of it is merely such as to admit of fertilization, by a series of operations more or less expensive and laborious. Where cultivation has not been extended, the soil produces nothing but heath and fir. As the property of such lands may be acquired for a very small sum, many individuals

Netherlands. have attempted to bring portions of it into cultivation, but have almost uniformly found the expence of doing so far exceed the value of the produce that can be drawn from it. Abbé Mann, to whom we are indebted for some valuable communications on the subject of Flemish agriculture, observes, "What land is cultivated in the Campine of Brabant, is owing to the religious houses founded in it, especially to the two great abbeys of Tongerloo and Everbode. Their uninterrupted duration for five or six hundred years, and their indefatigable industry, have conquered the barren harsh sands, and rendered many parts of them highly productive. The method they follow is simple and uniform; they never undertake to cultivate more of this barren soil than they have sufficient manure for; seldom more than five or six bunders (fifteen or eighteen acres) in a year; and when it is brought, by labour and manuring, into a state capable of producing sufficient for a family to live on, it is let out to farmers on easy terms, after having built them comfortable habitations. From the undoubted testimony of the historians of the Low Countries, it appears, that the cultivation of the greatest part of these rich provinces took its rise from the self-same means, 800 or 1000 years back, when they were in a manner one continued forest." Although, from the destruction, dispersion, or diminution of the religious communities, by the French Revolution, the process of reclaiming other parts of the heaths has been suspended or rendered languid; yet the excellent agricultural practices, which a long series of years had ingrafted into the minds and habits of the sluggish peasantry, have been adhered to with a tenacity that is obviously distinguishable in all the other customs, as well as in the manners, dress, food, and religion of the people. Besides that general system of economy, which is indispensable to the success of all efforts, and which there enters into the minutest details of their husbandry, the two great objects which seem to be aimed at in all their operations, are the increase of those crops which afford sustenance for cattle, and the careful preservation of every substance that can be converted into manure, and returned again to the land, to renew its exhausted fertility.

Clover. The foundation on which the agriculture rests is the cultivation of clover, which seems indigenous, since none of the most ancient records notice its introduction, but speak of it as familiarly as of hay or oats. It is probably from this country that the plant in question has been, though but recently, slowly, and hitherto partially, introduced to the adoption of the farmers of Germany, France, and Great Britain. The clover in Flanders is sowed in every sort of grain, in wheat, rye, and winter barley, in the spring of the year, when the blades of those plants have acquired a growth of three or four inches; and with oats and summer barley at the same time with those seeds. It is also often sowed with flax; and, in general, the crops grown between those plants are more luxuriant than when sowed with the cerealia. It frequently happens when sowed with flax, that clover yields a heavy crop a few months after it is sown, two still more abundant crops the next year, and sometimes even three; and if, as it occasionally happens, it is suffered to stand another year, it will yield one heavy crop, and afterwards good pasture for cattle, till it is ploughed up to receive the seed of wheat, which usually follows it. The original strength of the plants which yield such abundant nourishment is due, undoubtedly, to the care taken in pulverizing the soil by frequent ploughings and harrowings, to the careful extirpation of all weeds, and to the copious stores of manure, and its complete amalgamation with the soil; but the successive harvests which the plants yield is attributed, and with apparent probability, to the top-dressings which are bestowed upon them. The top-dressings administered to the young clover consists either of rotten yard-dung, lime, pigeons' dung, or coal, or native turf-ashes, and is laid on as soon as the plants begin to extend themselves over the ground. Sometimes the plants are refreshed with a liquid manure, which will be hereafter noticed. These manures, though administered to the clovers, as far as they can be obtained, are found far inferior in powers of fertility to that substance which is most generally used, and whose effects form the theme of the praises of all who have witnessed the Belgian husbandry. The turf-ashes of Holland are sowed by hand on the clovers, in quantities varying from eighteen to twenty bushels to the English acre. This small quantity produces a most surprising, and almost magical effect. Within a few weeks after it is sown, a field where none, or but slight straggling plants are to be seen, becomes covered with a most abundant herbage. The parts of a field sowed with these ashes, at the first mowing, show their efficacy in a most striking manner, the clover being frequently a foot higher on such parts than on those where its sowing has been omitted. These ashes are found superior in efficacy to such as are made from the turf commonly used for fuel in Flanders, in so much, that one-third of the quantity is deemed to afford as great productiveness. We have no analysis of the turf-ashes of Flanders, by which we can form a comparative estimate of the proportional substances which create so vast a difference between the vegetative faculties of them and of the turf-ashes of Holland. The latter have been carefully analyzed by Mr Brande, Secretary to the Royal Society of London, who found them to contain

Silicious earth, . .	32 parts.
Sulphate of lime, .	12
Sulphate and muriate of soda,	6
Carbonate of lime, .	40
Oxide of iron, . .	3
	93
Impurities and loss, .	7
	100

These ashes are brought from Holland by the canals to Brussels, from whence they are conveyed by land carriage to the different farms where they are applied. Long practice has so convinced the Flemish farmers of their benefit, that a common proverb, in the patois of the country, may be thus translated: "He that buys ashes for his clover pays no-

Netherlands. thing, but he who does it not pays double." They are frequently fetched from the canal by persons who have to carry them forty or even fifty miles by land.

Manure. The abundance of clover produced from the soil of Flanders enables the cultivator to maintain a great number of cattle, principally cows, whose dung is managed with an attention and care that is highly worthy of imitation, and contributes to maintain, in a state of high fertility, that soil which yields the most exhausting crops. "The farmers," says the Abbé Mann, "supply the want of straw in the following manner: The peat, or sods, which are cut from the heath, are placed in the stables and cow-stalls as litter for the cattle. The ground under them is dug to a certain depth, so as to admit a considerable quantity of these peat sods, and fresh ones are added as the feet of the cattle tread them down into less compass. These compose so many beds of manure, thoroughly impregnated with the urine and dung of the cattle. This mixture produces a compost of excellent quality for fertilizing ground where corn is to be sown."

The most unique practice of the Flemish cultivators is the application of liquid manure. Under the farm buildings, large reservoirs are constructed, into which the draining of the dung, the urine of the cattle, and the contents of the privies, run. This receptacle is divided by rails, so as to prevent any more solid substances from coming into that part where the pump is placed, by which it is raised from the reservoir into the carts that convey it to the fields. The liquid in these receptacles is commonly increased in efficacy, by throwing into them, for solution, large quantities of rape-cake. This liquid manure, enriched by oil-cake in proportion to the purse, or the spirit, of the proprietor, is spread over the land, sometimes by hand; and by habit the workmen have acquired the tact of distributing it equally and in previously prescribed proportions over a whole field. More commonly it is conveyed to the fields in large casks on wheels, to the bung-hole of which is appended a wooden shoot, narrow at the top and broad at the lower extremity, which spreads the substance equally. For the flax and rape crops this manure is most liberally used. The quantity of this liquid applied to an acre of flax is commonly about 2500 gallons of English beer measure, in which about 1000 rape-cakes of three pounds each have been dissolved.

Productions. No country in Europe provides from its soil so great a quantity of sustenance for its inhabitants, so large a surplus of food for exportation, and such valuable commodities to exchange for articles of foreign growth, as Flanders. Besides wheat, rye, barley, oats, pease, beans, and buck-wheat; madder, rape-seed, hops, tobacco, clover-seed, mustard-seed, flax, hemp, poppy-oil, and some other productions, are raised beneficially, both for home consumption and for exportation. As the inhabitants are in every thing averse to innovation or improvement, the implements of husbandry are in a rude state, and very little variation is made from the examples set by their ancestors some centuries ago. The various machines used in England for abridging animal labour in husbandry are unknown, and the use of human beings in many operations is still retained there, for which horses and machinery are adopted with us. The same aversion to innovate is seen in the management of the cows, the sheep, and the pigs; the races not having been improved by crossing as in some other countries. The horses seem to have drawn more attention, and the race commonly seen is excellent for agricultural purposes, and for the road.

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Mines. The mines of this kingdom form but an inconsiderable portion of its wealth. They are wholly confined to the southern provinces of Liege, Hainault, and Namur, and yield only iron, calamine, and coals. The quantity of iron annually produced is, on an average, about 1000 tons, of calamine, about 750 tons, and of coals, 2500 tons. The turf commonly used for fuel is valued at L.500,000 annually. The clay-pits in the northern provinces, from which their porcelain is made, and the stone quarries in the southern provinces, especially in Liege, are considerable sources of wealth.

Fisheries. The fisheries of Holland, which were in some measure the foundation of its national prosperity and naval power, have greatly declined under the political calamities which the last thirty years have witnessed, and are yet by no means restored to their former flourishing state. At the beginning of the last century, the fisheries gave occupation to about 60,000 families, and consequently supported 300,000 persons; at present, the families so employed do not exceed 20,000. At that period, 1500 busses, of 40 tons each, were annually equipped for the herring fishery, whereas, in the year 1818, their number did not exceed 200. The whale and cod-fisheries now employ not more than 60 ships; and the fishery on their coasts, which once supplied the markets of England, is much diminished, though it still employs about 6000 boats. The whole of the gross product of the fisheries is estimated, by Dutch writers, at about L.1,000,000 Sterling annually.

Commerce. Although much declined from its former eminence, the foreign trade of the Netherlands is considerable, and, since the foundation of the new kingdom, has gone on gradually, though not rapidly, increasing. The period of the most prosperous condition of the foreign trade of Holland was that commencing with the first voyage to the East Indies, under Cornelius Houtman, in 1595, who seized a large portion of the possessions of Spain, or rather of Portugal, then subjected to Spain. The East India Company was established in 1602. It conquered the Molucca Islands in 1618; established at Batavia, on the Island of Java, the central point of their commerce and power, and opened a lucrative trade with Japan. From 1620 to 1650, Brazil and the West India possessions of Holland were acquired, and their establishment at the Cape of Good Hope was founded. In the middle of the seventeenth century, from 1640 to its close, the foreign trade of Holland to that of Great Britain bore the proportion of five to one. In the beginning of the nineteenth century, the trade of Holland, as compared with that of England, gradually declined, and the events which followed the Revolution in France reduced it to a very low ebb.

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Since the union of the two countries, the Batavians have become a more commercial people than before, and, on the whole, their foreign commerce is reaching a respectable station among the European nations. Since the year 1815, the average number of vessels, under the Netherland flag, that have passed the Sound, has amounted to about 1600. At present, the commerce of the Netherlands with England amounts to about 44,000,000 Dutch florins; with France, 38,000,000; with Spain, Italy, and Germany, 30,000,000 each; with the East Indies, 36,000,000; and with the West Indies, 29,000,000. Holland requires from foreign countries more than half of its bread corn, salt, wine, fuel, and metals; the former is, indeed, in some measure supplied from the southern parts of the newly established kingdom. The principal articles of export are cheese, butter, madder, tobacco, linen, paper, laces, cloths, leather, arms, cutlery, herrings and stock-fish, corn, spirits, whalebone, seed and fish oils, tobacco-pipes, and many articles of less note. Besides the exportation of its native commodities, this country has a considerable commerce in the valuable productions of both the Indies, which are brought to their ports, and from thence re-exported by sea to the more northern countries, or transmitted, by means of the navigable canals and great rivers, to the centre of middle Europe. This transit trade has in some years amounted to 36,000,000 pounds of coffee, 12,000,000 pounds of cotton wool, 14,000 hogsheads of sugar, 5000 pipes of rum, 100,000 pounds of cloves, 160,000 pounds of nutmegs, and 50,000 pounds of mace, besides other valuable spices.

Foreign Dominions.

The foreign settlements belonging to the kingdom of the Netherlands, having been given back by Great Britain at the treaty of Paris, are, in Asia, 1st, The Island of Celebes, as far as the Dutch possessed it, viz. Macassar on the west coast, with four fortresses and several factories; Monada, under which is Gorantolo, from which the principal exports are ivory, gold, and diamonds. 2d, Banda, with nine surrounding small islands. 3d, Amboyna, whose principal productions are cloves, mace, and cinnamon. 4th, Timor, one part of which belongs to Portugal, governed by a sub-prefect. 5th, Ternate, the principal of the Moluccas, where a civil and military governor resides. 6th, Palembang, on the island of Sumatra. And, 7th, Banjermassing, on the island of Borneo. The most considerable foreign establishment is, however, on the Island of Java, where Batavia, the capital, one of the largest cities of India, is the seat of active and extensive commerce. The number of subjects of the King of the Netherlands, including all the different races on this island, are estimated at two millions and a half, and those on the other islands which have been enumerated, at one million and a half. Besides these there are some factories of the Netherlands on the coasts of Coromandel and Malabar, and some in Japan and Persia. According to the statement of General Daendels,* the income derived from these settlements in the year 1811 amounted to 25,890,000 florins, and the expenditure to only 21,500,000; leaving a net product of 4,390,000 florins, or 440,000 pounds Sterling, at the service of the parent state. On the coast of Guinea the Netherlands have thirteen factories with forts, and small establishments. The principal of these are Fort Nassau and Fort Elmina. The number of their subjects is estimated at about 10,000. In South America this kingdom possesses the province of Surinam in Guyana, which extends over 6400 English square miles, and contains about 300,000 inhabitants, the greater part of whom are negro slaves of the African race. In the West Indies, the Islands of Curaçoa, St Eustatia, and St Martins, have been given back by Great Britain, and are estimated to contain 40,000 inhabitants. These islands are by no means fertile, and are principally valuable as depots for commerce, especially Curaçoa, from whence large quantities of European goods used to be exported to the settlements of Spain upon the continent.

Revenue and Expenditure.

The national income of the kingdom is derived from various direct and indirect taxes, which, together, amount, on an average, to about fourteen Rhenish florins, or twenty-eight shillings Sterling, to each individual. These taxes are varied according to the exigencies of the state, as estimated in the annual budget presented to the States-General. The budget of 1818 is reduced lower than that of 1816 by about one-tenth, the whole of which is covered by taxes raised within the year, and includes the interest on the public debt. The expenditure thus covered is distributed in the following manner:—

	Rhenish Florins.
Civil List,	2,600,000
The higher Boards of Government,	1,170,000
Secretaries of State,	320,000
Foreign Affairs,	853,000
Administration of Justice,	3,700,000
Office of Internal Affairs,	2,000,000
Protestant Worship,	1,325,000
Catholic Worship,	1,875,000
Public Instruction,	1,200,000
Department of Finances (including the Interest on the National Debt),	25,000,000
Marine Department,	5,500,000
Army,	22,000,000
Water Department, for Dikes, Sluices, Canals, &c.	4,700,000
Department of the Colonies,	1,100,000
Reserve Fund,	657,000
	74,000,000

National Debt.

Or about L. 7,500,000 Sterling. Among other causes which contribute to retard, if not prevent, a cor-

* See *Staat der neederländischen oostindischen Bezittingen, onder hat bestuur,* van der Gouverneur-General Herman Wilhelm Daendels, in der Jahren 1808—1811. Gravenhage, 1814.

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dial union betwixt the two dissimilar portions of this kingdom, the public debt is not the least considerable. This debt was almost wholly contracted by the Seven United Provinces, either during their existence as an independent government, or whilst under the yoke of France, when it was greatly augmented. It is also principally owing to the great monied capitalists of Holland. The Belgians are therefore dissatisfied with this burden, and the consequent taxes with which the Union has loaded them. The amount of the debt is as follows, viz.—

	Florins.
Deferred debt, on which no interest is paid, - -	1,131,000,137
Active debt, bearing interest,	510,000,000
Belgian debt, principally contracted formerly by Austria, and assumed by the Netherland Government,	34,466,679
	1,675,466,816

Or nearly L. 170,000,000 Sterling.

Armed Force.

The peculiar situation of this kingdom, established under the auspices of Great Britain, and designed as a check on the land side to act against any encroachments of France, renders it necessary to maintain many strong fortresses on the frontiers, and to keep up a respectable land force. A chain of strong fortifications has been planned, and in part executed, the expence of which is defrayed by the contributions inflicted on France when the Allies occupied it after the battle of Waterloo. The army of the Netherlands at present consists of about 62,000 men, formed into six military divisions. The same connection with Great Britain which induces the maintenance of so large a land force, has rendered it unnecessary to support a proportionably extensive naval armament. At present the fleet consists only of sixteen ships of the line and ten frigates, besides smaller craft. There seems no disposition to increase the number of their larger ships, but several frigates and corvettes are now building and equipping, which will somewhat augment that description of force.

Money, Weights, and Measures.

In the Belgic Provinces the French decimal system of weights and measures has been introduced, but is yet reluctantly adopted, except in the commercial cities. In the villages and small towns the weights and measures are very various, differing in almost each of them, but the decimal reckoning of money much more extensively prevails. In the Dutch Provinces accounts are kept in gilders, stivers, and pfenningers. The gilder is fifty-five kreutzers, or twelve Saxon groschen. The gold coins are, ruyders, value fourteen florins Rhenish, and ducats, five florins five stivers. Coins have recently been made of one, two, and three guilders, and of half and quarter guilders, which has been done to facilitate the decimal arithmetic in current transactions. Mints for coining these pieces are established both in Amsterdam and Brussels. The old silver coins still most commonly current are, ducatoons, three florins three stivers, rix-dollars, two florins ten stivers, and lowenthalars, forty-two stivers. The common weight of commerce is the shipspound of three hundred weight. The tonnage of ships is estimated by lasts, consisting of two tons, and the ton is a space so large as to contain as much sea-water as weighs 2000 pounds; thus a ship of 200 tons is of such capacity as to hold, when filled with sea-water, 400,000 pounds weight.

Netherlands || Norfolk.

See Metelenkamp, *de toestand van Nederlande;* Van der Palm, *Geschieden redekunstig Gederkscrift, van Neederlands Herstelling; Almanac Royal des Pais-bas pour l'an* 1819; *Handels-Geschicte von Flandern und Brabant,* Von A. F. W. Crome; *Anleitung zur kentniss der Belgischen Landwirthshaft,* Von J. N. Schwerz; Radcliffe's *Report on the Agriculture of Eastern and Western Flanders;* Abbé Mann's *Communications to the Board of Agriculture;* Jacob's *View of Germany and Holland,* 1820. (ww.)

Boundaries, Extent, and Divisions.

NORFOLK, an English maritime county, bounded on the northern and north-eastern sides by the German Ocean; on the south and south-east by the county of Suffolk; and on the west by the counties of Lincoln and Cambridge. The shape is nearly that of an ellipsis bounded by a convex line, a little indented on the western extremity. Its greatest length is fifty-nine miles, and its greatest breadth thirty-eight. Its square contents, as calculated by the late Arthur Young, amounts to 1830 square miles, or 1,171,000 acres. It is divided into thirty-three hundreds, and contains 1 city, 30 market towns, and 722 parishes.

Population.

According to the enumeration of 1811, the number of houses was 52,807; that of families 62,815. The families employed in agriculture were 31,454; those employed in trade and manufactures 23,082; and 8279 were engaged in other occupations. The inhabitants were 291,999, of whom 138,099 were males, and 153,910 females. In the preceding year the baptisms of males were 4741, of females 4671; the burials of males were 2800, of females 2920; the marriages were 2364.

Face of the Country.

The surface of this county presents less variety than any other in England. It is generally a level plain, with few undulations, and no bold or abrupt elevations. With the exception of some recently planted districts around the seats of noblemen and gentlemen, the woody parts of the county are very inconsiderable, and there is generally a great scarcity of the more umbrageous trees. The streams have almost all a languid and sombre appearance. Though, to the traveller of taste, the sameness and uniformity is wearisome, yet to him who directs his attention to the wealth and comforts of the districts through which he journeys, few countries can be more pleasing. The number and substantial appearance of the farm-houses, and even the cottages, the condition of the roads and fences, and the high cultivation of the fields, are marks of rural prosperity that are no where more striking. Some few portions on the eastern side of the county form exceptions to this general description, but they are inconsiderable when compared with the whole.

Climate and Soil.

From its exposure to the North Sea, the winters in Norfolk are usually severely cold, and the powers of vegetation are retarded to a later period of the year than in the western counties. In the hundred of Marshland the climate is not only cold, but damp,

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and the inhabitants are subject to intermitting fevers, which commonly attack all strangers who come to reside in that district. The soil of Norfolk is generally a light sand, or sandy loam, for though a part of the fens are within this county, and the district of Marshland consists of ooze formed by deposition from the sea, as well as a narrow tract of land on the banks of the river Waveney, yet these form but trifling exceptions to the general character of the soil of the county. Mr Arthur Young, in his *Agricultural Survey of Norfolk*, has made the attempt to classify the soils, and estimate their quantities. The difficulty of doing this with accuracy must be acknowledged by every one who considers the nice gradations which soils discover, and how various are their modifications. We give this estimate rather as an approximation to, than as absolute exactness:

Soils.	Square Miles.	Acres.
Light sand, -	220	140,800
Good sand, -	420	268,000
Marshland clay, -	60	38,400
Various loams, -	900	576,000
Rich loams, -	148	94,720
Peat, - -	82	52,480

Agriculture.

As the land of Norfolk, from the representation here given, appears to be far from being naturally of a fertile description, the great amount of its productions must be attributed to the excellent system of agriculture which has been here introduced and extended, and which, though scarcely calculated for most of the other districts of our island, is admirably adapted for the soil and climate where it is pursued. The foundation on which the whole system of its agriculture is built is the cultivation of turnips. These light soils are easily brought into a fine tilth, by repeated ploughings and harrowings, and their produce maintains so large a portion of live stock, that their manure, when carefully preserved and properly distributed, enriches the soil at every successive course more than it is impoverished by the crops of corn that are grown upon it. The land is thus in a constantly progressive state of improvement. The soil being so light, no deep ploughing is required, but such a repetition of moving it as will be sufficient to destroy the surface weeds, and to pulverize it effectually. This is easily effected by well constructed light ploughs, drawn by two horses, who are guided by reins in the hands of the man who directs the plough. In many instances a four course system of rotation is followed, consisting of turnips, barley, artificial grasses, and wheat. In some instances the artificial grasses are left two years, and then, after three or four ploughings, the wheat is sown. A very common rotation, provincially termed *the six course shift*, is wheat, barley (with or without clover), turnips, barley or oats, clover mown for hay, clover fed, and then wheat again. Both these systems, with the varieties of each, are founded on the principle that as much land shall be cultivated with green crops, which furnish sustenance for cattle, and thereby produce manure, as is destined to the growth of corn. The system of drill-husbandry is carried to a great extent, and the practice of planting or dibbling grain of all kinds has been of late years very much and beneficially increased. By perseverance in their excellent plans, many extensive portions of this county, especially in the north-eastern part of it, which were a few years ago deemed incapable of producing a wheat crop, now yield abundant harvests of that grain. Oats are but a small object of cultivation, but barley is deemed the most appropriate grain to the soil and climate, and is consequently sowed to the greatest extent, occupying nearly one-fourth of the arable land of the county. The increase of grain varies very considerably. On the heavy soils of Marshland and Flegg the produce of wheat is frequently six quarters, and of oats ten quarters to the acre; but as these districts form but a small proportion of the whole, the average quantity of wheat in the county is about three quarters to the acre, and of barley four quarters. In no part of the kingdom have the various mechanical inventions for facilitating agricultural labour been so generally diffused as in Norfolk, and the implements used there may well serve as models for the other counties. Besides the common grains, wheat, barley, oats, pease, and beans, this county yields mustard, saffron, flax, and hemp, but none of them in such quantities as to merit especial notice.

Live Stock.

The live stock of this county possess few peculiarly discriminative features. The horses, crossed by the breed of Suffolk, are bony, active, and hardy, and well adapted for husbandry or the road, and are almost universally used for agricultural labour, to the exclusion of oxen. The native cows were a small breed, not unlike those of Alderney and Guernsey, but have been improved by a mixture with the cows of the richer adjoining counties. The greater part of the cattle fattened in Norfolk are bought from the Scotch drovers, who bring them to the fairs about Michaelmas. They are fed on the banks of the rivers on the natural grass, or on the arable farms on turnips, till they become fit for slaughter. The number of Scotch cattle annually bought by the Norfolk farmers is estimated to vary from 15,000 to 20,000. The original sheep of Norfolk were a hardy race, with horns, black feet, and black noses, the fleece yielding about two pounds of wool of third rate fineness, and the quarters weighing, when fattened, about eighteen pounds. They were well calculated for the land when it was less highly cultivated than at present, as they were good travellers, and eat the herbage very close; but as the improved systems of husbandry have been extended, this native breed has sometimes been crossed by others, and in many instances has given place to the South Down sheep. The increase of arable farms has diminished the dairies, and consequently the pigs which were reared from them, and the practice of fattening hogs for bacon is scarcely known.

Poultry and Game.

The poultry of Norfolk has been long celebrated, and vast quantities of it are conveyed to the London markets. The turkeys are most highly prized from their superior delicacy of flavour. The dry nature of the soil is deemed peculiarly favourable to the rearing of these birds, and the numbers that are sent from it to other districts amount to hundreds of thousands, No part of England is so abundantly stock-

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ed with game, especially pheasants and partridges, as Norfolk. They are sedulously preserved by the landlords, and generally reserved in the leases, so that they have obtained the character of property, and are commonly respected as such by adjoining proprietors of estates. Great numbers of rabbits are bred on extensive warrens in many parts of the county, both for the sake of the flesh and the wool.

Manufactures.

Norfolk has been long and still continues an extensive manufacturing county. The Flemings first settled here as early as 1336, and made woollen goods at the village of Worstead, from whence the name of that place was applied to the thread made of the longer kinds of wool. Under the persecutions of the Duke of Alva, in Flanders, many more natives of that country found refuge in and near Norwich. The fabrics have indeed successively changed with the change of fashions, and the fluctuations of markets, but manufactures have been continued through many vicissitudes, to the present time. The chief goods now manufactured are bombazeens, camblets for the markets of China, and shawls of various and elegant kinds, principally for home consumption. This last article, introduced when the demand for stuffs from Spain ceased, has been highly beneficial to the city of Norwich and its vicinity. The introduction of machinery in the northern counties had destroyed the habit of spinning, which, a few years ago, universally prevailed among all the females of the peasants' families in this and the adjoining counties. Besides the manufactories of Norwich and its vicinity, in Diss, and some other parts of the county, some inferior kinds of bone lace are made, but the quantity produced is slowly and gradually diminishing.

Commerce.

Scarcely any of the goods manufactured in this county are sent to foreign markets directly; those destined for distant countries being almost wholly exported from London. The commerce is notwithstanding very extensive from the two ports of Yarmouth and Lynn. Yarmouth, in regard to the number of its ships, is the eighth port in the kingdom, having more than 300 registered vessels. It is well situated for trade, and has one of the finest quays in Europe; but the depth of water is not sufficient for ships of great draft, and the bar at the mouth of the harbour is a serious impediment. The great support of the shipping of Yarmouth is the herring-fishery. These fish are caught by the Yarmouth men, in June and July, on the shores, and in the lochs of Scotland, and at a later period on their own coasts. They are first cleaned, and then slightly salted; after which they are hung up in large appropriate houses, where, by the application of the smoke of wood fires, the preparation of curing them is completed. This fishery usually yields from 80,000 to 100,000 barrels of red herrings, each barrel containing 1000 fish. This branch of industry, besides the employment of the seamen, gives occupation to several thousand artificers of various kinds. Besides this fishery, the exports of Yarmouth as well as Lynn, and the smaller ports of Wells, Blackney, Burnham, and Clay, afford great employment to shipping by the surplus quantity of corn which the county produces and sends to London and other ports. The imports at these towns consist of timber, hemp, wine, spirits, and foreign fruit, which, by means of the navigable rivers, are forwarded to the interior adjoining counties.

Interior Navigation.

The rivers are sufficiently easy of navigation to render canals unnecessary, and there are consequently none in the county, though some have been commenced, and, after languishing some time, have been abandoned without being completed. The Great Ouse is a navigable river, which rises in Northamptonshire, enters this county at Downham, and empties itself into the sea near Lynn. It has a great rise of tide; is navigable for barges twenty-four miles from its mouth; and for boats as far as Bedford; thus affording water communication with seven of the midland counties. The Little Ouse rises in the southern part of this county; at Thetford it receives the small river Thet, and from thence is navigable to its junction with the Great Ouse, on the borders of Cambridgeshire. The Waveney rises within nine or ten feet of the source of the Little Ouse, and takes a directly opposite course. It has many sinuosities, as its name denotes, becomes navigable at Bungay, receives the Yare at Burgh, and empties itself into the sea at Yarmouth. The Bure rises near Aylsham, and, after joining the Thone, near North Walsham, becomes navigable for boats. It falls into the Yare previous to its meeting the sea. The Yare rises near Attleburgh, becomes navigable at Norwich, and, after receiving the waters of the Tass and the Wensum, merges in the Waveney. The Nar rises near Litcham, has a short course to the sea at Lynn, from whence it is navigable upwards to Narborough, a distance of fifteen miles.

Political State.

The whole of the county is within the diocese of Norwich; the bishop of which see has his palace and cathedral in the city. The titles derived from the county are Duke to the family of Howard; Earl of Norwich to the Scotch Duke of Gordon, and of Yarmouth to the Marquis of Hertford, Marquis and Viscount Townsend; Viscount Thetford to the Duke of Grafton; Barons Walsingham, Calthorpe, Wodehouse, Hobart, Walpole, and Nelson. Norfolk sends twelve members to the House of Commons, viz. two for the county, and two each for Norwich, Yarmouth, Lynn, Thetford, and Castle-Rising.

Antiquities, &c.

This county contains few Roman antiquities, but some of Saxon date are to be seen in the cathedral, the episcopal palace, the gates of Yarmouth and Lynn, and in several piles of ruins of ecclesiastical edifices, and in some of the parish churches. Among many distinguished natives of this county, the most celebrated have been Queen Anne Boleyn, Dr Samuel Clarke, Sir Edward Coke, Archbishops Herring and Parker, Lord Nelson, Richard Porson, Sir Robert Walpole, and the Right Honourable William Windham.

In so large a county many seats of noblemen and gentlemen are naturally expected to be found. It would far exceed the limits which the nature of this work admits to enumerate one half of them, but the most remarkable are the following:

Bickling, Lord Suffield; Binley Hall, Earl of Rosebery; Bracon Ash, T. F. Berney, Esq.; Bucken-

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ham House, Lord Petre; Costessey Hall, Sir Wm. Jerningham; Felbrigg, Captain Lukin; Harling, Sir John Sebright; Hethel Hall, Sir Thomas Beevor; Hillington Park, Sir Martin Folkes; Houghton Hall, Watson Taylor, Esq.; Intwood Hall, Earl of Buckinghamshire; Gunton, Lord Suffield; Kimberley Hall, Lord Woodehouse; Kirby Bedon, Sir John Berney; Melton Constable, Sir J. H. Astley; Quiddenham, Earl of Albemarle; Rainham Hall, Marquis of Townsend; Wareham, Sir M. B. Folkes; Wolterton Hall, Earl of Orford; Oxburgh Hall, Sir Richard Boddingfield.

The towns whose population exceeds 1500 inhabitants are the following:

	Houses.	Inhabitants.
Norwich, - -	8521	37,256
Lynn, - -	2318	10,259
Wells, - -	603	2,683
Thetford, - -	528	2,450
North Walsham, -	447	2,035
Aylsham, - -	362	1,760
Yarmouth, -	3576	17,977
East Dereham, -	554	2,888
Diss, - -	352	2,590
Swaffham, -	485	2,350
Market Downham,	383	1,771
Harlestone, -	278	1,516

See A. Young's and Kent's *General View of the Agriculture of Norfolk; Topographical History of Norfolk; The Norfolk Tour*, 1808; Booth's *History of Norwich;* Gough's *Topography;* Richards's *History of Lynn;* Brayley and Britton's *Beauties of England*, Vol. II. (W. W.)

Extent.

NORTHAMPTONSHIRE, an inland county of England, nearly in the centre of the kingdom. It is of an irregular and very extended figure, being about 67 miles in length. In the widest part it is 30 miles, and in the narrowest not more than eight in breadth. Its contents are 965 square miles, or 617,600 acres. The land is thus appropriated; about 290,000 acres are in arable cultivation, 235,000 acres are in pasture, and about 86,000 are uncultivated, or occupied as forests and woodlands. It contains one city, eleven market towns, 301 parishes, and is divided into 1901 liberties.

Population.

In the year 1811, the county was returned as containing 28,957 houses, with 30,860 families, and 141,353 inhabitants. The families employed in agriculture were 15,235, those engaged in trade and manufactures were 12,100, and those of other descriptions 3525. Of the inhabitants, the males were 68,279, and the females 73,074. In the preceding year, the baptisms of males were 1973, of females 1896; the burials were of males 1276, and of females 1323, the marriages were 1090.

Boundaries.

From its oblong shape, lying obliquely across the middle of the kingdom, Northamptonshire comes in contact with, and is bounded by, a greater number of other counties than any other division of England. Proceeding from the north, on its western side, it touches upon Lincolnshire, Rutlandshire, Leicestershire, Warwickshire, and Oxfordshire; and on its eastern side, it is bounded by Buckinghamshire, Bedfordshire, Huntingdonshire, and Cambridgeshire. The whole of the county is within the diocese of Peterborough, with the exception of three parishes that are under the see of Lincoln.

Northamptonshire.

Face of the Country.

It is generally a pleasant country, with such undulations as give an agreeable variety; but, owing to the numerous inclosures, the prospects are not in general extensive, except upon the summits of the higher hills. The centre of the county is a level elevation, from which the rivers have their rise, and descending in opposite directions, take a course both to the German Ocean and the English Channel.

Agriculture.

The agriculture of this county partakes so much of the nature of the several counties that border it as to be almost as various, and not to merit any particular description. The most important rural pursuit is the grazing of cattle, for which the excellent pastures are admirably adapted. These, when fattened, are sent in weekly droves to the market of Smithfield for the supply of the metropolis, where they are highly esteemed. The arable land produces excellent wheat, beans, and oats; but the soil in general is not well calculated to raise good barley. The artificial grasses, clover, trefoil, sanfoin, and rye-grass, are very extensively cultivated, and, aided by turnips, form important articles of food for the flocks and herds.

Forests.

Within this county are several large forests belonging to the Crown, with two chaces, over which the King has certain rights. The largest of these is the Forest of Rockingham, in the northern part of the county; it extends over 11,000 acres. The land, in many instances, belongs to individuals; but the royal deer have, under certain restrictions, the range over the whole. Whittlewood Forest contains about 5000 acres. It is stocked with about 1000 deer; a proportion of which, according to ancient prescription, are killed annually for the royal household and for the great officers of the Government, who receive them as a matter of right, attached to their appointments. This forest contains much excellent naval timber, which is reserved for the use of the Government; but, from the reports of the commissioners, appears to be very negligently preserved, and very injudiciously managed. Salcey Forest is about 1850 acres. This tract was formerly covered with most valuable ship timber, but has furnished for the navy but a very small proportion of what it is capable of. The mixture of opposite interests in this kind of property diminishes its productiveness to all the parties interested in it. The underwood does not belong to the Crown. The individuals who own it cut it down every twenty-one years. During the following nine years it is inclosed, and for the remaining twelve is open for the deer to feed on the land. The Crown enjoys only this right of pasture and the timber trees. The pasture does not belong exclusively to it, for many of the surrounding parishes possess also a right to turn their cattle into the forests, under ancient grants and prescriptions, and with limitations, of a complex nature, which are productive of perpetual dissensions and litigations. The rangership of these forests is hereditary in the Dukes of Grafton, who have, during the last century, derived from it a very large income, whilst the revenue to the Crown has been very trif-

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ling; scarcely amounting to L. 200 *per annum* on an average of the last hundred years.

Rivers and Canals.

The only navigable river in this county is the Nen or Nine. It rises in the western part, flows across, and then runs north, till it enters by Lincolnshire into the German Ocean. The Welland rises in the county, soon forms the boundary between it and Leicestershire and Rutlandshire, and only becomes navigable after entering Lincolnshire at Stamford. The other rivers, the Ouse, the Avon, the Leam, and the Charwell, though they have their sources in Northamptonshire, are but inconsiderable rivulets till they enter the contiguous counties. The benefits of internal navigation have been very freely bestowed here by the canals, which afford great facilities to intercourse. The Oxford Canal connects it with that city. The Grand Junction Canal, communicating on one hand with London, and on the other with Liverpool and Manchester, passes through the county. The Grand Union Canal connects it with Leicester. Thus the heavy products, especially coals, are brought to every part on very moderate terms.

Antiquities.

The remains of Roman and Saxon antiquities are very numerous. Among the former, the Watling Street Road, the Ermine Street Road, the camps of Arbury, of the Boroughs, and of Rainsbury, and the tesselated pavements at Cotterstock, at Stanwick, and at Woodford Field, have engaged the attention of Stukely and other eminent antiquarians. As there were more than sixty monasteries and other religious houses at the period of the Reformation, whose traces may now be seen, they, with the baronial castles, present a wide field for the researches of the lovers of antiquity; but the bare enumeration of them would be incompatible with the limits of this work.

Manufactures.

The manufactures of this county are chiefly of a domestic nature, and carried on in the dwellings of the workmen. Boots and shoes are made for foreign markets, and, in war, for the supply of the army. Both fine thread and silk lace are made, and afford employment to the females, who are taught the art in schools for that purpose, and attain great perfection. The principal places for collecting the lace are Northampton and Wellingborough. A large quantity of horse whips were made at Daventry, and though diminished in some degree, the trade is still continued there.

Titles, &c.

The titles derived from this county are Duke of Grafton; Marquis of Northampton; Earls of Peterborough, Fitzwilliam, Spencer, and Harrington; Viscount Sackville; Barons Braybrooke and Lilford; and as second titles, Baron Burleigh to the Marquis of Exeter, Viscount Milton to Earl Fitzwilliam, Viscount Brackley to the Earl of Bridgewater, and Baron Finch to the Earl of Winchelsea. The members returned to the House of Commons are nine, viz. two for the county, two each for Northampton, Peterborough, and Brackley, and one for Higham Ferrers.

The most celebrated natives of Northamptonshire have been, Robert Browne, founder of the sect of Independents; Mrs Chapone; John Dryden the poet; Fletcher the dramatist; Fuller the historian and divine; Harrington, author of the *Oceana*; Hervey, author of *Meditations* and other works; Knolles the historian of the Turks; Dr William Paley; Bishop Wilkins, and Thomas Woolston.

Northamptonshire || Northumberland.

The catalogue of all the noblemen and gentlemen's seats in this county would extend to a long list, and we, therefore, can only notice the most remarkable of them.

Castle Ashby, Marquis of Northampton; Aldwinckle, Lady Lilford; Althorpe, Earl Spencer; Apethorpe, Earl of Westmoreland; Brinworth, Walter Strickland, Esq.; Burleigh, Marquis of Exeter; Canons Ashby, Sir J. E. Dryden: Cottesbroke, Sir James Lanham; Courteen Hall, Sir William Wake; Dean, Earl of Cardigan; Drayton, Duke of Dorset; Easton Neston, Earl Pomfret; Ecton, Samuel Isled, Esq.; Fawsley Park, Sir Charles Knightley; Finedon Hall, Sir William Dolben; Horton, Sir Robert Gunning; Kirby, George Finch Hatton, Esq.; Lamport, Sir Justinian Isham; Lilford, Lord Lilford; Martin's Thorpe, Earl of Denbigh; Milton Abbey, Earl Fitzwilliam; Rockingham Castle, Lord Sondes; Salcey Forest, Earl Euston; Wakefield Lawn, Duke of Grafton; Walgrave, Sir James Langham; Whittlebury, Lord Southampton.

The towns whose population exceeds 1000 are the following:—

	Houses.	Inhabitants.
Northampton,	1600	8427
Peterborough (city),	829	3674
Wellingborough,	746	3999
Kettering, -	732	3242
Daventry, -	550	2758
Towcester, -	479	2245
Oundle, - -	377	1833
Long Buckby,	368	1631
Brackley, -	293	1580
Rothwell, -	330	1451
Middleton Cheney,	246	1172
Raunds, -	211	1101
Welford, -	195	1024
King's Sutton,	229	1020
King's Thorpe,	229	1009

See Pitt's *General View of the Agriculture, &c. of Northamptonshire;* Morton's *Natural History of Northamptonshire;* Whalley's *History and Antiquities of Northamptonshire;* Brayley and Britton's *Beauties of England and Wales*, Vol. II.

(W. W.)

Boundaries, Situation, and Extent.

NORTHUMBERLAND, an extensive county in England, situated on its northern extremity, on the borders of Scotland, from which it is separated partly by the river Tweed, which, during the latter part of its course, flows between this county and Berwickshire, and partly by a line supposed to be drawn over the mountainous region on the west and northwest, where it meets with Roxburghshire. The other boundaries are the German Ocean on the east, Durham on the south, Cumberland on the west, and on the north two small districts called Norhamshire and Islandshire, which, though belonging by their situation to Northumberland, form a part of the county of Durham, along with another tract, called Bedlingtonshire, on the south-east. But in a general description, it is unnecessary to attend to these

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distinctions. The Tweed may, therefore, be considered as the northern boundary of the county, and, in this case, it will include the towns of Berwick and Norham. Lindisfarne, or Holy Island, on the north-east coast, which, in like manner, belongs to Durham, is situated about two miles from the mainland, opposite the mouth of the brook Lindis, and accessible to all kinds of conveyance at low water. Though about nine miles in circuit, it contains little more than 1000 acres, half of which is sand-banks. These several portions may extend to something more than 100 square miles, or about one-twentieth part of the whole. In this view, Northumberland is situated between 54° 51′ and 55° 48′ north latitude, and between 1° and 2° 27′ west longitude from London. Its greatest extent from north to south is 64 miles, and from east to west, it varies from about 46 miles, which is its usual breadth between the river Tyne on the south and the Coquet on the north, till it terminates at Berwick, on the north, in a breadth of only five or six miles. According to the authors of the *Agricultural Report*, the extent of the whole is 1980 square miles, or 1,267,200 acres, of which nearly two-thirds may be fit for cultivation.

Divisions.

It is divided into six wards, namely, Tindale, Coquetdale, Glendale, Bamborough, Morpeth, and Castle, the first three comprising the western and mountainous district, and the latter three the coast lands on the east. These last, though extending over only one-fourth of the county, are by far the most wealthy and populous, owing chiefly to the great coal-works in Castle ward, near the town of Newcastle, and along the banks of the Tyne. It contains five deanries and seventy-three parishes, all of which are in the archdeaconry of Northumberland and diocese of Durham.

Surface.

All the western side of this county is mountainous, from the boundary with Durham on the south, almost to the valley of the Tweed on the north; but this extensive tract, comprising more than a third of the whole area, is not all of the same character; the northern, or Cheviot hills, extending to about 90,000 acres, being mostly all green nearly to their summits, enclosing many narrow but fertile glens, and affording excellent pastures for the breed of sheep, to which they have given their name; while those to the west and south are, in general, open, solitary wastes, covered with heath, and of very little value. On the coast, from the mouth of the Tyne to that of the Tweed, and also on the north, for its whole breadth from Belford to Mindrum, the country is, with few exceptions, level and rich, with a soil, in some places, a strong clay, and in others a dry loam; but almost every where very productive, under the enlightened system of cultivation which prevails so generally throughout Northumberland.

Rivers.

The principal rivers are the Tyne, Blyth, Wansbeek, Coquet, Aln, and Tweed, all of which fall into the sea, carrying with them the tribute of many smaller streams. The Till, which empties itself into the Tweed, is also a considerable rivulet. The Tyne and Tweed are by far the most important, the tide flowing up the former sixteen miles, and up the latter eight or ten miles, while the navigation of the other rivers is confined to a small distance from their mouths. Both of these have been long celebrated for their salmon-fisheries, which yield great rents, and afford a valuable article of trade with London, to which the fish are sent packed in pounded ice, by which means they are presented in the market in nearly as fresh a state as if they had been newly taken from the water.

Coal, &c.

Northumberland has been long distinguished for its subterraneous treasures, the main source of its wealth and population. Of these, coal, which abounds in most parts of it, is by far the most important. It is of the best quality in the south-east quarter, on the banks of the Tyne, from whence those vast quantities are exported which supply the great consumption of the metropolis, as well as the coasting and foreign trade. In some years, the export from the port of Newcastle has amounted to upwards of 600,000 chaldrons of 53 cwt. each; and probably as much more has been sent from Sunderland and consumed in Northumberland and Durham,—the same coal field extending across the Tyne to the latter county. This coal is all of the kind called "caking coal," which melts and runs together in the fire, and, when of the best quality, leaves very few ashes. Calculations have been made as to the extent of this tract, the quantity which it may contain, and the period when it must be exhausted; but on this last point there is a great difference of opinion, some estimating that the supplies must cease in 300 years, some not in less than 800, while by others it is held to be almost inexhaustible. Of the coal found in Bamborough, Islandshire, and Glendale ward, the seams are, in general, thin, and the quality inferior, not caking or burning to a cinder, but yielding a great quantity of ashes. This is used only for home consumption and for burning limestone; for the latter purpose it is well adapted; and through all this district, coal and lime are generally found together. The south-east quarter, which is so rich in coal, is destitute of limestone. Lead-ore abounds in the mountains on the south-west, particularly towards the head of that branch of South Tyne called Allendale, where it has long been wrought to a considerable extent. Iron-ore is found in many parts; stone marl near Tweedside, shell marl in Glendale ward, and various sorts of sandstone, or freestone, are got in almost every quarter, some of it affording tolerable slates for roofing, and flags for floors. Excellent grindstones are raised in those sandstone quarries, of which a great many are exported from Camus and Warkworth.

Agriculture.

The agriculture of Northumberland is an object only second in interest and importance to its coal-works. Almost all those branches of rural economy, for one or more of which other districts are celebrated, may here be found combined into one system, and conducted upon the same farms. One finds here the Leicester sheep and the short-horned cattle of Durham and Yorkshire, both in great perfection; the turnips of Norfolk cultivated upon the drill system of Scotland; the well dressed fallows of East Lothian and Berwickshire; and that regular alternation of tillage and grazing which is, of all other courses of cropping, the one best adapted to sustain

Northumberland || Nottinghamshire.

and improve the productiveness of the soil. These remarks apply in an especial manner to the northern part of the county, where the farms are in general large, and the occupiers men of education and liberal acquirements. This quarter has been long distinguished as a school of agriculture to which pupils are sent, some of them gentlemen of fortune, from various parts;—a character for which it is eminently indebted, as well as for other distinctions, to the late Messrs Culley, who were among the most extensive and successful farmers in the kingdom. The common period of leases, at least in the northern district, is 21 years, though many are shorter, and on a few estates no leases are granted. In 1795 the rental was stated, conjecturally, at L. 605,000, in 1809 it was L. 916,857, 18s. 11½d. It is worthy of remark, that at Chillingham near Belford, the seat of the Earl of Tankerville, there is a herd of wild cattle, perhaps the only remains of the ancient race to be now found in a pure state. An accurate description of them has been given in the *Agricultural Report* of Messrs Bailey and Culley.

Wild Cattle.

Manufactures.

Northumberland is not the seat of extensive manufactures; its principal establishments of this kind are derived from the coal trade, or connected with it, such as ship-building, roperies, forges, &c. On the Tyne there are a great many glass-houses, which a few years ago paid a duty of L. 180,000 yearly; and Hexham has been long noted for its manufacture of gloves.

Principal Towns, Population, &c.

The principal towns are Newcastle, North Shields, Morpeth, Alnwick, Berwick, Norham, and Wooler. The county sends two members to Parliament, and Newcastle, Morpeth, and Berwick, two each,—eight in all. Northumberland contains a great many elegant seats; but for these, and for its history and antiquities, we must refer to the *Beauties of England*, Vol. XII., and the works there enumerated.

The census of 1811 gives the following returns for this county:

Houses inhabited,	28,258
——— uninhabited,	1,126
Families employed in agriculture,	10,945
——————— trade and manufactures,	16,547
All other families,	10,251
Total inhabitants,	172,161

See Bailey and Culley's *General View of the Agriculture of Northumberland*. (A.)

NORWAY, see SWEDEN.

Boundaries and Extent.

NOTTINGHAMSHIRE, an inland county of England; bounded on the north by Yorkshire and a part of Lincolnshire; on the east by Lincolnshire; on the south by Leicestershire; and on the west by Derbyshire. It is of an oval figure, with its narrowest end towards the north. Its greatest length is about 50 miles, and its greatest breadth 27. Its circumference is estimated to be 140 miles, and its contents 776 square miles, or 496,640 acres.

Divisions and Population.

The county is divided into six hundreds, or, as they are usually denominated, wapentakes; three of which are to the north, and three to the south of the Trent. It contains 9 market towns, and 207 parishes. In the year 1811 the number of inhabitants was 162,900, in 32,298 houses. The males were 79,057, the females 83,843. The families were 33,514, of whom 12,293 were employed in agriculture, 18,928 in trade and manufactures, and 2293 followed neither of those pursuits. In the year preceding the census the baptisms of males were 2407, of females 2386; the burials of males were 1791, of females 1787; and the marriages were 1372. The towns, whose population exceeds 1500 inhabitants, are the following:

	Houses.	Inhabitants.
Nottingham,	6801	34,253
Newark,	1492	7,236
Mansfield,	1453	6,816
Worksop,	756	3,702
Greysley,	597	3,673
Radford,	725	3,447
Sutton in Ashfield,	679	3,386
Arnold,	710	3,042
Basford,	573	2,940
Southwell,	557	2,674
East Retford,	469	2,030
Bulwell,	560	1,944
Hucknall-Torkard,	317	1,793
Clareborough,	356	1,551

Face of the Country and Climate.

The face of the county is generally level, with moderate undulations; and its beauties are of a mild description, somewhat picturesque in the vicinity of Sherwood Forest, but displaying neither the striking features of the adjoining county of Derby on its western side, nor the flat insipidity of the plains of Lincolnshire on its eastern side. From its position between these two descriptions of country, and from its moderate elevation, it enjoys a milder climate than either; partaking neither of the raw air of the one, nor the moist atmosphere of the other. The dryness of the climate is favourable to early vegetation, and is supposed to be the cause of the seed-time and harvest in Nottinghamshire commencing at the same period as in the more southern counties.

Soil and Rural Economy.

The soil of this county is very various. On the borders of Derbyshire is a stripe of land with coal and limestone, partly in wood, but mostly under arable culture. Parallel to it is a broader track including Sherwood Forest, whose soil is chiefly sandy and gravelly, which, though naturally sterile, has in some degree been brought into a productive state by the extensive cultivation of turnips, and the maintenance of considerable flocks of sheep. The track which adjoins is a clayey soil, extending to the banks of the river Trent. It is chiefly arable land, but varied with woods and meadows, and highly productive of wheat, oats, beans, and, in some parts, of hops. The lands on the banks of the Trent are very fertile, mostly devoted to pasture, on which many oxen are fattened, and some of the dairies are extensive. The arable land of this district is celebrated for both the quantity and the quality of the oats that it produces. The beautiful Vale of Belvoir in the south-easternmost part of the county enjoys some of the best soils both for pasture and arable husbandry of any part of this island. The farms are in general small, and commonly held by tenants at will; the rents from whom were generally moderate, and a

Nottinghamshire. very great proportion of the land is free from the burden of tithes. The spirit of agricultural improvement has not proceeded so far as in many other counties, though it has made considerable progress of late years. Neither the breeds of cows and sheep, nor the modes of cultivation, differ so much from those of the adjoining counties as to deserve any especial notice.

Mines. There are no mines except those of coal, which are exclusively confined to a narrow district bordering on Derbyshire; these are of good quality, very abundant, and, by means of internal navigation, diffused through the whole county. Excellent stone for building is raised in many parts, some of which has the peculiarly valuable quality of improving by exposure to the weather. Many parts of the county abound in veins of gypsum. In the parish of Gotham, it is found in strata of the thickness of three feet. At Beaconhill, near Newark, are large quarries of this substance. Although it has been much praised as a manure, the trials of it that have been made in its vicinity have not been attended with such beneficial results as to induce the continued use of it for that purpose.

Sherwood Forest. The Forest of Sherwood, formerly celebrated as the scene of the exploits of Robin Hood, whose deeds amused our nursery days, is mostly an open heathy plain, bordered with recent plantations, and upon which the plough has made very extensive encroachments. The boundaries of the forest are extensive, it being twenty-five miles in length, and from seven to nine in breadth; but a great portion of it is become the property of private individuals, and is enclosed in farms and parks; in the latter of which alone are to be found the deer with which this forest was once most abundantly stocked. The trees of most ancient date are those now remaining on the estates of the Duke of Newcastle and Lord Manvers.

Manufactures. Nottinghamshire is, for its population, one of the greatest manufacturing counties. The frames for making hosiery were the discovery of a clergyman of this county named Lee, in the reign of Queen Elizabeth, who, finding but little encouragement in England, repaired to Paris, and commenced his work under the auspices of Henry the Fourth. The murder of that monarch having deprived him of a patron, he died in France of chagrin, and the workmen returned home, when, after many fluctuations, the machinery was introduced in this county. The making stockings, caps, pantaloon-pieces, and other similar articles, has long given employment to the great mass of the labouring population; and of late years, the making of lace, upon a similar principle, has been introduced, and created additional employment. Although the riotous conduct of the workmen, under the denomination of *Luddites*, has driven some of the large capitalists to other parts of the kingdom, yet the hosiery business is by far the most important means of employment throughout the whole county. The spinning of cotton-yarn, from its natural connection with hosiery, has been introduced, and very widely extended; and the establishments at Nottingham, at Mansfield, at Newark, at Southwell, and several other places, are upon an extensive scale. There are also several large manufactories for spinning worsted yarn. Malting and brewing are carried on to a considerable extent; and the beer of Nottingham and of Newark rivals that of Burton upon Trent. There are potteries at Sutton Ashfield; starch is made near Southwell; and sailcloth and candlewick at Retford.

Commerce. The foreign trade of this county is mostly conducted by the mercantile houses of London and Liverpool; but some of the larger manufacturers export their own goods, both to the Continent of Europe, and the more distant parts of the world.

Rivers and Canals. The river Trent, the fourth in magnitude of the English streams, passes across the county, and is navigable for barges through the whole of it; but its deficiencies of water and its shoals are such great impediments, that a canal by the side of it, ten miles in length, is found of great use to the intercourse. The other rivers are not navigable, but are beneficial for the purposes of irrigation. They are the Erwash, the Soar, the Maun, the Meden, the Wollen, the Worksop, the Idle, the Lene, and the Dover or Dare. These all discharge their waters into the Trent. The canals are the Nottingham, the Grantham, the Idle, and the Chesterfield. The last of these is about forty miles in length; the others about ten. By means of these and the Trent, the intercourse by internal navigation is extended to almost every district of the county.

Titles, &c. The titles derived from this county are, Marquis of Granby; Earl of Mansfield; Viscount Newark; and Barons Pierrepoint and Carrington. Eight members are returned from it to the House of Commons, viz. two for the county, and two each for the boroughs of Nottingham, Newark, and East Retford. The whole county is in the diocese of York.

Antiquities. The remains of Roman and Saxon antiquities are numerous. Amongst the former are the camps at Barton hill, at Combes farm, at Gringley, at Hexgrave, and Wenny hill, and a Roman villa near Mansfield: among the latter are the Castle of Newark; the Abbeys of Newstead, Rufford, and Welbeck; the Priories of Mattersey and Worksop; and the Churches of Bingham, Blythe, Southwell, and Balderton.

Celebrated Natives. The most distinguished natives of this county have been, Archbishop Cranmer, Dr Erasmus Darwin, Sir Martin Forbisher, Denzil Lord Holles, Ireton, the son-in-law of Cromwell, Lady Mary Wortley Montague, Paul Sandby, Archbishop Secker, Gilbert Wakefield, and Bishop Warburton.

The seats of noblemen and gentlemen of the first class are as numerous as in any county of England; of which the most remarkable are the following, viz. Annesley Hall, J. W. Chaworth, Esq.; Babworth Hall, Honourable J. B. Simpson; Bunney Park, Lord Rancliffe; Clifton Grove, Sir Gervas Clifton; Clipstone Park, Duke of Portland; Clumber Park, Duke of Newcastle; Colwich Hall, John Musters, Esq.; Grave, A. H. Eyre, Esq.; Holme Pierrepoint, Earl Manvers; Hurgarton Hall, G. D. L. Gregory, Esq.; Kelham House, J. M. Sutton, Esq.; Langold, H. Gally Knight, Esq.; Lenton Priory, William Stretton, Esq.; Muskham, J. Pocklington, Esq.; Newstead Abbey, late Lord Byron (lately sold to Major Wildman); Norwood Park, Sir Richard Sutton, Bart.; Osberton, F. F. Foljambe, Esq.; Ossington Hall, J. Denison, Esq.; Rufford Abbey, Honourable J. L.

Saville; Stanford Hall, C. V. Dashwood, Esq.; Stappleford, Sir John Borlase Warren; Thoresby Park, Earl Manvers; Welbeck Abbey, Duke of Portland; Wollaton Hall, Lord Middleton; Worksop Manor, Duke of Norfolk.

See Dickinson's *Antiquities in Nottinghamshire;* Thoroton's *History of Nottinghamshire;* Lowe's *Survey of the Agriculture of Nottinghamshire;* Rooke's *Sherwood Forest;* and Brayley and Britton's *Beauties of England and Wales.* (W. W.)

ORGANIC REMAINS, FOSSIL.

The occurrence, in rocks of various kinds, of remains of animals and vegetables, more or less altered, is so remarkable and striking a fact, that it could not fail to attract the notice of mankind, even at an early period. Xenophanes of Colophon is said to have described the remains of fossil fishes found in the stone quarries of Syracuse, and in the deep marble rocks of Paros. Not long after, in the fifth century before Christ, Herodotus mentions fossil shells as occurring in the rocks of Egypt, and states this as a proof of that country's having been formerly an arm of the sea, like the Red Sea. We find some allusions to fossil organic remains even in the poets of antiquity. The following passage from Ovid is an example of this kind:

> Vide ego, quod fuerat quondam solidissima tellus
> Esse fretum, vidi factas ex aequore terras,
> Et procul a pelago conchæ jacuere marinæ.
> Et vetus inventa est in montibus anchora summis.
> *Metamorph. Lib. XV. v. 62.*

But our author confounds true organic remains with the accidental occurrence of an anchor in soil. Not long after the commencement of the Christian era, attempts were made to connect these phenomena with the Deluge of Noah; and in the writings of Tertullian, there are passages that refer to this supposed connection. This opinion afterwards became general, particularly towards the beginning of the eighteenth century, when it was attempted to prove, or at least to illustrate, the truths of revelation by appeals to natural history. Thus Büttner, in his *Zeichen und Zeugen der Sundflut*, published at Ulm, in 1710, and Scheuchzer, in several of his works, as in his *Homo Diluvii Testis, Piscium Querelæ et Vindiciæ, Herbarium Diluvianum*, &c. enumerate many facts, and state numerous reasons in illustration of the accumulation and deposition of fossil shells, plants, and animals, during a great flood, which they maintain to have been that described in the *Old Testament*. But the non-occurrence of the remains of man along with those of other animals came to be considered as inimical to this opinion, and by the time of Knorr it was nearly abandoned. Another speculation was soon started in its place, by which it was attempted to show that these remains were not truly organic, but merely efforts of nature to produce organic beings; and, therefore, that these bodies, although exhibiting the organic form, had never been animated. This fancy was combated by the supporters of the diluvian hypothesis, and the result was, the addition of many new facts, and the total abandonment of both hypotheses. The discovery of remains of elephants, rhinoceroses, &c. in Europe and Northern Asia in a fossil state, gave rise to a new opinion, that these, and many other fossil animals found along with them, had been floated hither from the tropical regions. Forster, Pallas, and others, who advocated this opinion, brought together a host of facts in support of it; and, in this way, contributed, in an eminent degree, to our knowledge of fossil organic remains, and to a more accurate investigation of their various characters and relations. But their speculation, with all its plausibilities, was soon supplanted by that which is at present considered as the most consistent with facts—namely, that the various fossil organic remains, contained in rocks of different kinds, belong to animals and vegetables that formerly lived in the countries where these remains are at present met with. The facts which have been brought to light by the collision of opposite opinions, and by the careful and successful investigations of many naturalists who were contented to view these fossil remains, not as connected with any general geological hypothesis, but as interesting additions to zoology and botany, and important contributions to our knowledge of the physical and geographical distributions of animals and vegetables, are so interesting, even to the general reader, that we shall attempt to give a short account of them, in the following order:—

1. Different kinds of fossil organic remains.
    1. Animal remains.
    2. Vegetable remains.
2. State or condition of these remains.
3. Geognostical situations.
4. Formation of the strata in which these remains are contained.

I.—DIFFERENT KINDS OF FOSSIL ORGANIC REMAINS.

I.—Fossil Remains of Animals.

1. *Fossil Remains of the Human Species.*—When the diluvian controversy was keenly agitated, many descriptions were published of fossil remains of man, said to have been found in secondary rocks of different kinds; but all these, without exception, proved to be remains of the lower animals. Thus the famous

"homo diluvii testis" of Scheuchzer was found to be a gigantic fossil salamander. The fossil bones of Cerigo, so confidently described by Spallanzani as human, were determined to belong to quadrupeds. The remains of the human species, therefore, do not occur in the secondary strata; but the following facts prove their occurrence in fissures of rocks and in post-diluvial strata. Human bones, and even whole skeletons, have been found in clay in fissures of rocks, being the remains of bodies that had fallen into them; in other cases, human bones and skeletons have been met with, and occasionally more or less mineralized, in old deserted galleries in mines. Some years ago, human skeletons were discovered in a compact calcareous rock in the Island of Guadaloupe. A mass of this rock, inclosing a pretty well preserved human skeleton, but without the head, and wanting the right arm (represented at fig. 1, F, Plate CII.), was sent by Admiral Cochrane to Lord Melville, and afterwards by him deposited in the British Museum. The rock, on examination, proved to be a mere alluvial mass, formed of pieces of coral, that appear to have been thrown up on the shore by the sea, and afterwards united together by water impregnated with calcareous matter. M. Moreau de Jornes thinks these skeletons are remains of persons who had perished by shipwreck. Human bones have lately been found in alluvial soil at Köestritz in Germany, and in such a situation as to render it probable that they are of great antiquity. The absence of human fossil remains from diluvial formations has excited surprise; but this will cease when it is recollected that, probably, at the period of the deluge, the human race had not extended into the countries where fossil organic remains have been examined, and, therefore, are only to be looked for in those regions where man is known to have lived when that event took place.

CLASS I.—Mammalia.

Order I.—*Quadrumana.*

Hitherto no fossil remains of apes, baboons, monkeys, or other tribes of the order Quadrumana, have been met with; although it is probable that they will be found among the alluvial strata of those regions where these animals now live.

Order II.—*Chiroptera.—Bat.*

It is probable that fossil species of the larger bats will be found in the alluvial strata of the warmer regions of the earth, and that remains of the smaller European species will be discovered in some of the European formations. The only fossil remains of the animals of this order with which we are acquainted are those represented, fig. 5, Plate CII. These are contained in a slab of limestone from Eichstädt, and belong to a species which must have measured six or seven feet from the tip of one wing to the tip of the other. The remarkable fossil tribe named Ornithocephalus, to be described afterwards, in general aspect bears a striking resemblance to bats.

Order III.—*Marsupialia.*

Two species of this order, both belonging to the genus *Didelphis, or Opossum,* have been met with in a fossil state; the one was found in the gypsum of Paris, the other in the calcareous oolite slate of Stonesfield in England.

Order IV.—*Glires, or Gnawers.*

Fossil remains of an animal resembling the *Cavia porcellus,* or Guinea-pig, have been detected in the limestone of Oningen; remains of an animal resembling the *Lagomys alpinus,* a species at present confined to the higher parts of Siberia, were found in the fissures of the rock of Gibraltar; two species of *Lepus,* one nearly resembling the *common rabbit,* and the other one-third less, were found in the limestone rocks of Cette; three species of Mus have been met with in a fossil state, one nearly resembling the *Mus terrestris,* occurs in limestone in Bohemia, and also in the limestone-conglomerate of Corsica, and two others, one referred to the *Mus arvalis,* and the other to the *common water-rat,* in the rock of Gibraltar: fossil remains of the *common beaver* have been met with in alluvial strata in Perthshire and Berwickshire in Scotland, and in similar situations on the Continent; and another species, named *Castor trogontherium,* was found on the shores of the sea of Azof.

Order V.—*Bradypoda.—Sloth.*

The fossil species of this order, although not numerous, are remarkable for their magnitude and singular organization. Hitherto only two species have been discovered, and apparently both belong to the same genus: the one is the Megatherium, and the other the Megalonyx, of authors. We might assume Megatherium as the generic denomination, and name the South American species Megatherium Australe, and the Megalonyx, or North American species, Megatherium Boreale; but our present view will be answered by describing them under their common names.

Megatherium.—A complete skeleton of this colossal species was found in diluvial soil near Buenos Ayres, and sent to Madrid; afterwards another was discovered near Lima, and a third in Paraguay.* The splendid specimen in Madrid is fourteen feet long, and seven Spanish feet in height. The skeleton of this megatherium is so rude and unshapely, that the clumsy skeleton of the elephant and rhinoceros, and even the massive and rugged bones of the hippopotamus, appear, when placed beside it, slender and light. It is one of the largest and most massive of all the fossil quadrupeds hitherto discovered. Judging from its structure, its motions seem to have been slow and dragging, and, with exception of its long claws, appears to have been more defenceless than any of the other large quadrupeds. The form of the

* Remains of the Megatherium have been lately found in limestone caves in Brazil.

teeth shows that it lived on vegetables, and its long claws are supposed to have been used for digging up the roots on which it is conjectured to have fed. Plate CIII. exhibits a correct representation of this animal from the specimen in the museum at Madrid.

Megalonyx.—This species is smaller than the megatherium, being only the size of the ox. The general form and arrangements of the skeleton are the same as in the megatherium, and the agreement is so considerable, that some naturalists conjecture, although without sufficient ground, that it is a young variety of the megatherium. It appears also to have been herbivorous, and hitherto its remains have been met with only in limestone caves in Virginia.

Order VI.—Feræ.—Rapacious Animals.

Ursus.

Several fossil species of this tribe have been met with in different parts of Europe. The following are enumerated by naturalists:

1. *Ursus Spelaeus.*—It is the largest species, and is distinguished from the Polar bear, to which it bears a close resemblance, by its more inclined brow, and the want of the anterior small grinding tooth. 2. *U. Arctoideus.*—The skull smaller than the preceding, and the small anterior grinding tooth also wanting. 3. *U. priscus.*—Not larger than the brown bear; the cranium the same shape, and provided with the same teeth.

These fossil species occur in limestone caves in Germany and Hungary.

Canis.

Fossil remains of a species of canis resembling the *dog*, and of another nearly allied to the *common fox*, and bones of the *common wolf*, have been found in post-diluvial and diluvial soils, and in caves in England, Germany, and France.

Hyæna.

Fossil remains of a species nearly allied to the *common hyæna* have been found in caves in limestone in Yorkshire. In these also dung was found, proving that these caverns had been the residence of the hyæna. Remains of the same species occur in caves in Germany. Another species, resembling the *H. crocuta,* was found in Hanover, in marl, along with bones of the lion and elephant.

Felis.

One species of this tribe, and nearly resembling the *jaguar* of South America, has been found in a fossil state in limestone caves in Germany; another species, nearly allied to the *tiger,* is found in diluvial soil, along with fossil remains of the elephant, rhinoceros, hyæna, and mastodon.

Mustella.—Weasel.

Two species of this genus occur in the German limestone caves. The one is allied to the common *pole-cat* (Mustella putorius), and the other to the *zorille,* a pole-cat, native of the Cape of Good Hope. Another species, allied to the *ichneumon* of Egypt, but nearly double its size, occurs in the gypsum quarries around Paris.

Order VII.—*Solidungula.*

Equus Adamiticus—Equus Caballus.—Fossil teeth of a species of horse are found in diluvial soil, associated with those of the elephant, rhinoceros, hyæna, mastodon, and tiger. These teeth are larger than those of the present horse, and, to all appearance, belong to a different species, which inhabited the countries where they are now found, as Great Britain, along with elephants, rhinoceroses, hyænas, bears, wolves, &c.

Order VIII.—*Bisulca.*

Many fossil animals of this order occur in a fossil state. We shall enumerate the principal of these.

Bos.—Ox.

Four species of this genus occur in a fossil state. 1. *Bos aurochs* or *urus.*—This species is considered as distinct from the common ox, being much larger. Horns and bones are found in this country, and also on the Continent of Europe. It occurs likewise in alluvial soil in the district of Ohio in North America. 2. *Common Ox.*—The fossil skulls of this species differ from those of the present existing races in being larger, and the horns having a different direction. They are considered as belonging to the original race of the present domestic ox. The remains are of frequent occurrence in our peat-bogs, also in a similar situation in Ireland. 3. *Large Buffalo of Siberia.*—Skulls and bones of a large species of ox are found in Siberia, which Cuvier maintains to be different from any of the present species; and as it occurs in the same situation as the elephant and rhinoceros of Siberia, he considers it to have lived at the same early period. 4. *Fossil Ox, resembling the Musk Ox of North America.*—The bones of this species resemble in many points those of the musk ox, but the marks of difference are so considerable as to show that it is a distinct species. This species has hitherto been found only in Siberia.

Cervus.—Deer.

The following are the fossil species. 1. *C. elephas, or Red-Deer.*—Horns and skulls of a deer, agreeing in almost every particular with the common red deer, are occasionally met with in strata of different descriptions. Some of these have been found in the newer secondary formations, in supposed ancient volcanic tufas, and in diluvial strata, with remains of the elephant, rhinoceros, &c. and lastly in our common peat-mosses. The horns and crania found in our peat-bogs are of the same species with our present red deer, but it is not equally certain that those found in the older formations are of the same description. 2. *Roe-Deer.*—Bones of this species are met with in our peat-mosses, and in beds of shell marl, but never in any of the diluvial strata. 3. *Fossil Roe of Orleans.*—This species, nearly allied to the roe, but different as a species, is remarkable on account of its geognostical position, its remains occurring in a new secondary limestone, along with bones of the palæotherium. It occurs near Orleans in France. 4. *Fossil Fallow-Deer.*—This species is found in peat-bogs and in marl pits in Scotland, England,

and in different parts on the Continent of Europe. The antlers are in general larger than those of the present varieties. 5. *Fossil Deer of Etampes.*—This species appears nearly allied to the rein deer, but much smaller, not exceeding the roe in size. The bones were found near Etampes in France, in a sand, the geognostical relations of which have not been determined. 6. *Cervus giganteus, Irish Elk, or Elk of the Island of Man.*—This gigantic and magnificent species, now apparently extinct, occurs in a fossil state in Ireland, Isle of Man, England, Germany, and France. The most perfect specimen of the skeleton of this species hitherto met with is that which was found in the Isle of Man, and now preserved in the Museum of the University of Edinburgh. In Plate CIV. we have given an accurate representation of this remarkable specimen. It is six feet high, nine feet long, and in height to the tip of the right horn, nine feet seven and a half inches. It was dug up in the parish of Kirk Balaff, and fortunately secured for the Museum by his Grace the Duke of Atholl. It was imbedded in a loose shell marl, in which were numerous imbedded branches and roots. Over the marl was a bed of sand, above the sand a bed of peat, principally composed of small branches and rotten leaves, and over the peat the common soil of the country.

Order IX.—*Multungula.*

Several of the largest and most remarkable of the fossil species of quadrupeds belong to this order, and of those the following are the most interesting:

Rhinoceros.

Of this genus four fossil species have been determined. 1. *Rh. tichorinus.*—In this species the nostrils are separated by a thick osseous plate. It is the largest of the fossil rhinoceri, and is that which is found in England, France, Italy, Germany, Siberia, &c. One specimen was found in the year 1770 with its skin on, imbedded in ice, on the banks of the Wilhoui. It appeared to have had very long hair on its feet, an arrangement, according to Cuvier, probably connected with the climate which it inhabited. 2. *Rh. ptorhinus* (from λεπτος, *thin*).—In this species the nostrils are not provided with an osseous septum, the bones of the nose are thinner, and the skeleton less massive than in the preceding species. It is found in Italy. 3. *Rh. minutus,* of a diminutive size.—Found in diluvium in the village of St Laurent, near to the town of Moissac, in the department of the Tarn, and the Garrone. 4. *Rh. incisorus,* provided with incisor teeth. It is the size of the common rhinoceros, and is found in Germany.

Hippopotamus.

Only one living species of this tribe is known to naturalists, but four fossil species have been determined by Cuvier. 1. *H. magnus.* It is very nearly allied to the present living species, and is of the same size. It is found in England, France, Germany, &c. 2. *Middle-sized Hippopotamus,* is smaller than the former, being the size of a hog, and is found in France. 3. *Small Hippopotamus.*—Found in France; is less than the second species. 4. *Least Hippopotamus.*—Found in France, and appears to have been the size of the hog of Siam.

Elephant.

Of this interesting tribe of animals two living species, the Asiatic and African, and one fossil species, named *Mammoth* by the Russians, are known to naturalists. The fossil elephant or mammoth differs from the living species in the following particulars: The alveoli of the tusks are much larger, and the zygomatic arch of a different form. The vacuity between the branches of the jaws at the fore part is wider than in the Asiatic and African species; and the lower jaw, in place of terminating in a kind of pointed apopysis, as in the living species, is rounded off. The grinders of the fossil species differ from those of the living, and the tusks, although of the same magnitude, appear to be more curved than in either the Asiatic or African species. Single bones and teeth, or even perfect skeletons, are found, and one instance is on record of the whole animal being found preserved in ice. This specimen was discovered in the year 1799 in Asiatic Russia. The flesh, skin, and hair, were completely preserved,—even the eyes were entire. It was provided with a long mane, and the body was covered with hair. This hair was of different qualities. There were stiff black bristles, from twelve to fifteen inches long, and these belonged to the mane, tail, and ears. Other bristles were from nine to ten inches long, and of a brown colour; and, besides these, there was a coarse wool, from four to five inches long, of a pale yellow colour. This latter is the wool which lies next the skin in all the inhabitants of cold countries; and hence, Cuvier thinks it probable that the northern fossil elephants, or those of Siberia, Russia, &c. were inhabitants of cold countries.* Its remains have been found in Iceland, Norway, Scotland (in Ayrshire and West Lothian), England, and in many places throughout the Continent onwards to the Arctic Ocean. But they are more abundant in Siberia than in other countries; for Pallas informs us, that there is scarcely a spot from the Don to Kamtschatka where they have not been met with. They also occur in North America, even as far north as Churchill, Hudson's Bay; this latter being the locality of a specimen sent to us from that country; and teeth and bones of a fossil elephant have been found in South America.†

Mastodon.

This remarkable genus of fossil multungular ani-

* The wide distribution of this fossil species, and its occurring alongst with remains of numerous large feline animals, &c. would seem to show, in opposition to the above inference, that the climate of the countries it inhabited had a tropical character.

† There are in the Ashmolean Museum at Oxford, some vertebræ and leg bones of an elephant of vast size, probably sixteen feet high, found in gravel near Abingdon. Mixed with these were bones of the rhinoceros, hippopotamus, horse, dog, ox, and a species of deer.

mals, first systematically arranged by Cuvier, was named by him Mastodon (from Μαςτος, *mamilla*, and ὀδȣς, *dens*), in reference to the mamillary or tubercular processes on the grinding teeth. The following are the species at present known to naturalists: 1. *Great or Gigantic Mastodon of the Ohio.*—This species appears to have been as tall as the elephant, but with longer and thicker limbs; probably provided with a proboscis or trunk, and had tusks like those of the elephant. It appears to have lived on roots and fleshy parts of plants, and hence this kind of food attracted it to soft and marshy places, where its fossil remains are principally found. It is more common in North America than in any other part of the world, although its remains have also been found in Siberia. 2. *Mastodon with Narrow Grinders.*—It is smaller than the great mastodon, and the grinders are narrower in proportion to their length than in the great mastodon. It is found in Europe, and also in North America. The teeth and bones of this species when of blue colour, from mineral impregnation, are named Animal Turquois. Besides the great mastodon and the species with narrow grinders, remains of four others have been met with, but their characters are not well known. Two of them are from America; the one is named *Mastodon of the Cordilleras,* and the other *Mastodon of Humboldt;* the other two are European, and of these one is named *Small Mastodon,* the other the *Tapir-like Mastodon.*

Tapir.

The tapir was long held as peculiar to America, but the late discovery of a species in Malacca shows that it also extends to the Old World. The living species are different from those in a fossil state. These latter are found in the same diluvial strata as afford the fossil elephant and mastodon. Two species have been determined. The one, named *Gigantic Tapir,* about eighteen feet long and twelve feet high, thus equalling in magnitude the great mastodon of America and the great elephant, has been found in France, Italy, and Germany: The other is smaller, but still a formidable animal, and occurs in the same countries.

Lophiodon.

This is a newly discovered fossil genus, nearly allied to the tapir, and named from the eminences on its teeth. Twelve species have been ascertained by Cuvier, and one of them, the largest, is of gigantic dimensions. All of them are found in what is called a fresh water formation, of the same nature with that which contains the remains of the palæotherium and anoplotherium, and hitherto they have been met with only in France and Germany.

Elasmotherium.

Of this newly discovered fossil genus but one species has been found, and that in Siberia. It appears from the few fragments in the Museum at Moscow, and described by Fisher, to be nearly allied to the rhinoceros and horse, and that probably it forms an intermediate tribe between these two. It is the size of the rhinoceros.

Palæotherium.

This genus, like the two preceding, is entirely fossil. Its generic character, as given by Cuvier, is as follows: Dentes quadraginta quatuor; scilicet, Primores utrinque sex; laniarii quatuor, acuminati paulo longiores, tecti; molares viginti octo; utrinque septem; quorum superiores quadrati, inferiores bilunati. Nasus productior flexilis. Palmæ et plantæ tridactylæ. In general osteological arrangement it resembles the tapir. Like that tribe, it appears to have had a lengthened snout, or short proboscis, and there can be little doubt that the form of the body was nearly the same as that of the tapir. Ten species are described by Cuvier, and these vary in magnitude from that of the rhinoceros to the hog and sheep, and all of them appear to have been herbivorous. None of the species have been hitherto found in this country, and those described by Cuvier occur in new secondary and diluvial strata in different parts of France, particularly in the vicinity of Paris.

Anoplotherium.

This also is a fossil genus of extinct herbivorous animals. It bears some resemblance to the camel, and the tail is of equal length to the body, if not longer, being at the same time very thick and strong. There are but five species known, and all of these, as far as we know, are found only in the new secondary rocks around Paris. The following is the character of this genus, as given by Cuvier. Dentes quadraginta quatuor, serie continua. Primores utrinque sex; laniarii primoribus similes, cæteris non longiores; molares viginti octo, utrinque septem; anteriores compressi; posteriores superiores quadrate; inferiores bilunati. Palmæ et plantæ tridactylæ, ossibus metacarpi et metatarsi discretis; digitis accessoriis in quibusdam.

Sus.—Hog.

Bones and teeth of the common hog occur in peatmosses, and similar remains of a dubious species of hog in loam, along with remains of the elephant and rhinoceros.

Order X.—*Palmata, Palmated Quadrupeds.*

Under this head we include those tribes provided with four paws somewhat resembling fins, and sometimes provided with clawed toes.

1. *Phoca, or Seal.*—Two fossil species of this genus have been found in France, in the coarse marine limestone of the formation above chalk. One of them appears to have been three times as large as the common seal, and the other of rather smaller dimensions.

2. *Trichecus, or Sea Horse, or Walrus.*—No well marked fossil remains of this genus have hitherto been met with.

Order XI.—*Sirenia.*

Lamantin, or Manatus.—Several bones of an unknown species of this genus have been discovered in the coarse marine limestone formation in the department of the Maine and Loire.

Order XII.—*Cetacea.*—*Whale.*

Mr Parkinson says that two teeth of the narwal, or Monodon monoceros, were found on the coast of Es-

sex, in the London clay, and that one specimen was found in the limestone of Bath. Fossil remains of dolphins and whales are mentioned as occurring in the new secondary formations of Italy; and we know that a skeleton of the common whale was found near Airthry in Stirlingshire, imbedded in alluvial soil formed by depositions from a river in a marine estuary.

CLASS II.—Ornitholites, or Fossil Birds.

Fossil remains of birds are of rare occurrence, and the few specimens hitherto found afford results much less satisfactory than those obtained by the study of the fossil bones of quadrupeds. The best information on this subject is furnished by Cuvier, who has also communicated some obvious characters for assisting in the determination of this class of organic remains. Among others, the following are enumerated:—The foot in birds has a single bone in place of the tarsal and metatarsal bones of quadrupeds; birds, too, form the only class in which the toes all differ as to the number of joints, and in which this number, and the order of the toes which have them, is nevertheless fixed. The great toe has two; the first two, reckoning on the outside, three; the middle five, and the outermost five. The crocodile has the same number of phalanges; but, as these have a tarsal and metatarsal bone, they cannot be confounded. By attention to these and other characters, fossil remains of species of the following genera have been determined, viz. *owl, buzzard, starling, ibis, quail, curlew, tern,* and *pelican.* These occur in the limestone and gypsum of the Paris formations, and, it is said, also in an older formation, viz. that into which the Stonesfield slate enters as a member. *

Ornithocephalus.

This genus, which is entirely fossil, is so remarkable in its structure, that naturalists are not agreed as to its place in the system. Some, as Cuvier, refer it to the Amphibia; others, as Blumenbach, to the birds; Collini described it as a fish; while Sömmering arranges it with the Mammalia, and near to the bats. In this state of uncertainty, it is of little consequence where we place it. The skull is very large in proportion to the size of the skeleton, the jaws themselves being longer than the body, and furnished with sharp slightly incurvated teeth. In general form, the head of the O. longirostris resembles that of the curlew tribe, while the brevirostris more nearly resembles the bat, particularly the Vespertilio murinus. The orbits of the eyes are disproportionably large, and hence it is probable that, like the bat, it was a nocturnal animal, while, from the size of its jaws, it is likely that it fed on small flying insects. There are four legs, the hinder ones being of considerable length. There are no tarsal bones, only metatarsal bones and claws. There is a distinct tail. Two species are described by Sömmering, the largest, which is about a foot long, is named *O. longirostris*; while the other, which is less, is named *O. brevirostris.* They are represented in Plate CII. Both species occur imbedded in the limestone of Eichstädt.

CLASS III.—Amphibia.

Testudo.

Several species of this tribe have been detected in formations of different descriptions. In England they have been met with in the lias limestone near Bristol, in the oolite of Stonesfield, but most perfect in the London clay, as it is termed, in the vale of Sheppey. Cuvier and other naturalists enumerate different species of land, marine, and fresh water fossil testudines found in France, Germany, and Italy, but all of them apparently extinct species.

Crocodile.

Two species were found in a blue clay (resembling that below chalk) in the neighbourhood of Honfleur and Havre. They cannot be referred to any of the present species. In England, one specimen was obtained from the Purbeck stone, and another was found in the cornbrash rock at Gibraltar, in Oxfordshire. These are distinct from the first French species, but perhaps may agree with the second. Vertebræ, apparently of that species, are found in clay near Weymouth, and in chalk in Sussex.

Mosasaurus of Conybeare.—Lacerta Gigantea of Sömmering.

This tribe contains those fossil amphibia which differ from crocodiles in some important characters, and is considered as an intermediate genus between those animals of the lizard tribe with a short tongue, and whose palate is furnished with teeth, and those where the tongue is long and forked. The gigantic species found in the soft limestone of Maestricht has long excited the attention of naturalists. The length of the skeleton appears to have been nearly 24 feet. The head is a sixth of the whole length of the animal, a proportion approaching very near to that of the crocodile. The tail must have been very strong, and its width at its extremity must have rendered it a most powerful oar, and have enabled the animal to have opposed the most agitated waters.

Fossil remains of an animal of the same kind, found in Bavaria, are described by Sömmering, under the name *Lacerta gigantea*; all the known parts of which are represented in Plate CV. "When it is considered," says he, "that this gigantic lizard was 24 feet long, we are forcibly reminded of the dragons so much spoken of in fable. At least, the fact that, at one period of the world, there existed animals of the lacerta, or dragon tribe, more than 20 feet in length, is more astonishing than all that is recorded in ancient tradition respecting monsters, which even the wildest fancy did not amplify to such enormous dimensions."

Ichthyosaurus.

This is a marine oviparous animal, closely agreeing in the whole osteology of the head, and sternum,

* Cuvier has lately found in Montmartre an ornitholite, in which the head, neck, wings, tail, thighs, and even the trachea arteria, are well preserved.

with the saurian tribe, except that the bones are usually, as in fish, united by squamous sutures, and approximating to fish in some parts of the structure of its vertebral column, and, in others, being *sui generis*. From these double analogies the name (fish-like lacerta) is derived. The extremities terminate in four swimming paws, or paddles, composed of a series of flat polygonal bones, greatly exceeding in number, not only the phalanges of quadrupeds, but also the phalangic cartilages of the fins of fish. Three distinct species, distinguished from each other by their teeth, are found in the lias limestone in England.

Plesiosaurus.

From πλησιος, approximate to, and Σαυρος, a lizard. —This newly discovered fossil animal appears to be intermediate between the crocodile and ichthyosaurus, but whilst the ichthyosaurus recedes from the forms of the lizard family, and approaches those of fishes, the new animal approximates, in these respects, more nearly to the crocodile; the plesiosaurus is, therefore, a marine animal, intermediate in structure between the ichthyosaurus and crocodile. It also occurs imbedded in lias limestone in England.

Megalosaurus.

From μεγαλος, great, and Σαυρος, a lizard.—This is a species nearly allied to the monitor in the mode of its dentition. It is found in the calcareous slate of Stonesfield, in England. The animal must, in some instances, have attained the length of forty feet, and stood eight feet high. The gigantic lizard of Sömmering appears diminutive when contrasted with this stupendous being.

Monitor.

Fossil remains of animals that appear to belong to some of the numerous species comprised by Linnæus under the name *Lacerta monitor*, and of *Tupinambis* by Daudin; animals which frequent marshes and the shallow beds of rivers, occur in bituminous marl slate in Thuringia.

Salamandra.—Salamander.

Scheuchzer's famous *Hommè fossil*, which is considered to be an extinct species of salamander, was found in the limestone of Œningen.

Bufo.—Toad.

Fossil remains of this animal occur in the slate limestone of Œningen. It is not the common toad, but one nearly allied to the Rana calamita.

Coluber.

Several accounts have been published of the occurrence of fossil serpents in rocks of different formation, but all of them, with exception of the notice of Cuvier, are so loose and unsatisfactory, as to be undeserving of notice. In the notice alluded to, we are informed the bones of a snake, resembling the Coluber natrix, were found in the calcareous conglomerate of Montpellier.

CLASS IV.—Fossil Fishes.

Fossil remains of fishes occur in considerable abundance in formations of particular descriptions, but hitherto, owing to the difficulties attending the investigation, the determination of the genera and species has been far from satisfactory. Even the attempts that have been made to divide these fossil fishes into fresh and salt water species have generally failed, and the whole geognostical history is in such a state, as to require a complete revisal. The fish, in some specimens, are found nearly entire, with the soft parts, and even the scales, preserved by mineralization. In others, all the parts are removed, except the skeleton, and this is more or less perfect, and frequently only the hardest parts remain, such as the palates and teeth. Fossil fishes are found in a variety of geognostic situations in Great Britain, and the following genera are mentioned by authors as occurring in this island: *Balistes, Xiphias, Diodon, Anarchichas, Salmo, Esox, Zeus, Murœna, Squalus*, but of this latter only the teeth, and of the *Raia* only the bony tongue and palates.

Fossil Vertebræ.—Many figures, and some descriptions, have been published of the fossil vertebræ of fishes. Most of the specimens appear to have belonged to large species of fishes, and some authors have confounded, under this name, the caudal vertebræ of cetacea, which, however, are always easy to determine, as they do not present any traces of the deep and regularly disposed foramina, which present themselves at the surface of the vertebræ of fishes.

Fossil Teeth, or Ichthyodonta.—These are the parts of fishes that occur most frequently in the bowels of the earth, on account of their being less subject to decay. They are divided into two groups, the *glossopetra*, or more or less flattened teeth, which have belonged to fishes of the shark tribe, &c. and the *bufonites, batrachites, &c.* or more or less rounded teeth, which have been generally considered as belonging to certain species of sparus or of anarchichas. 1. *Glossopetræ, or Petrified Tongues.*—This denomination has its origin from the idea that was formerly entertained of the form of the tongue of serpents, and especially from the notion that the Apostle Paul, on going to Malta, had destroyed all the serpents of that island, and that the fossil teeth of sharks, which occur in great abundance, originated from them, and were nothing else than their tongues converted into stone. 2. *Bufonites, or Batrachites.*—We find figures, or rather descriptions, by authors under this name, derived from *bufo*, because it was imagined, we cannot say how, that there were engendered in the head of toads a great number of fossil bodies, of a more or less rounded shape and shining surface, which are evidently nothing else than portions of the teeth of fishes. Many of them are true teeth implanted in the maxillary bones, while others are maxillary plates.

CLASS V.—Crustacea.

1. *Fossil Crustacea, or Crabs.*

The description of fossil crustacea presents more difficulties than might at first be imagined. The greater number of them are in such a state of mutilation, or so inclosed in the rock, that very often there is nothing to be seen but a part of the upper

surface of the body, or of the thorax; while the under surface, composed of the numerous pieces of the plastron, or sternum, giving attachment to feet composed of many articulations, and presenting also the external parts of the mouth, is found completely fixed in the substances which inclose it. The antennæ and feet, besides, are most commonly broken and separated from the body; which may be readily conceived, when we recollect with what facility these latter parts are detached from living crustacea, which lose them when fighting with one another, or even when executing some violent motions. The general want of the antennæ and feet in the fossil specimens, induced Desmarest to restrict the distinctions to characters obtained from the shell or the thorax. On examining the thorax, it results that the various prominences which it exhibits are not irregular and accidental; on the contrary, in all the genera of crustacea, the disposition of these inequalities is constant, and subjected to certain laws. Reflecting, besides, that the crustacea have their principal internal organs situated immediately under the shell or thorax, Desmarest was led to inquire if there existed marked relations between the place occupied by these viscera and the distribution of the internal inequalities of the shell. We have been the more inclined, he remarks, to admit these relations, that it is known that at a certain period of the year all the crustacea, after having lost their old solid envelope, are covered with a delicate skin, which hardens in its turn, and at the end of a few days changes into a crust equally resisting with that which it substitutes; and we might presume, that in the first moments the new skin moulded itself to a certain point upon the internal organs, and that its ossification was subsequently influenced by the motions peculiar to these organs, or by the greater or less developement of each of them. It is easy to prove that the relations which we have just mentioned exist; for, if the shell of a crab of the most common species on our coast, the *Cancer mænas*, Lin. be removed with care, we observe, fig. 1, Plate CVI. behind the inter-orbitary edges, a membranous vesicular stomach, having two large lobes, *a a*, before, and two small ones, *á á*, behind, supported in the middle by a slender transverse bone in the form of an arch, *h h*, and having above, between the two great lobes, and on the middle line, two longitudinal muscles, *i i*, which are attached on one side to the anterior edge of the shell, and on the other to the transverse bone. If we make a comparative examination of the thorax, which is detached, fig. 2, we perceive on it, 1 1, the indication of the two anterior lobes of the stomach with a depressed central line, which corresponds with the interval that separates the two muscles mentioned.

Behind the stomach whitish sinuous bodies present themselves, fig. 1, *g g*, in the form of intestines, and making many circumvolutions. These are preparatory organs subservient to generation, the spermatic vessels in the males, and the ovaria in the females. They project beneath in different places, but above they occupy the same place in both sexes. With reference to the shell, fig. 2, these organs appear to us to occupy the space, 2, which is circumscribed by sunk lines, and which is seen behind the one corresponding to the stomach.

Still farther back, fig. 1, in a pretty deep hollow, we find the heart, *d*, which is depressed above, and which occupies its whole extent; this organ is easily distinguished by its pulsations. Each lateral edge of the cavity, *f f*, in which it is placed, is solid and much elevated, and formed by a vertical septum which proceeds from the sternum to the shell, and which contributes to its solidity, by being fixed between these two surfaces, much in the way of the supporter between the two tables of a violin. This septum also gives support to other transverse partitions, which are equal in number to the separations of the sternal pieces, and in the interval of which are situated the muscles which move the feet. The shell, fig. 2, 3, shows the place of the heart well defined, in the same situation in which this organ is found in the crab when laid bare, and on each of its sides we observe two small sunk lines, which belong to the point of attachment of the two bony partitions between which the heart is situated.

On the right and left of the preparatory organs of generation and of the heart, there are two large spaces, fig. 1, *e e*, where the branchiæ are arranged and extended on two oblique osseous tables, which shut up above all the compartments in which the muscles of the feet are fixed. These branchiæ are five in number on each side, and each of them presents a double row of small transverse branchial laminæ; this point of attachment is externally, and all their extremities are directed toward the line which separates the preparatory organs of generation from the heart. The shell, fig. 2, 5, 5, presents, above these parts, on each side of the body, a bulging space, which, in its extent, agrees perfectly with the place occupied by them beneath it.

Lastly, on both sides of the stomach, and before the branchiæ, we find the liver, fig. 1, *b b*, which is very large; it is of a soft consistence and yellowish colour, and its surface presents a multitude of small vermiform parts. This liver passes beneath the viscera which we have described, and is prolonged posteriorly, as far as the base of the tail to *e*, so that it is seen still behind the heart. At this point it has the same aspect and structure as in the anterior part of the body, and is divided into two lobes, which, besides, are in close contact. In the shell, the parts which cover the places where the liver is visible, when it has been removed, fig. 2, 6, 6, and 4, are less bulging than the others, and are distinct on account of this want of protuberance, especially the anterior ones.

The same relations have been found in the *Cancer pagurus*, and many other species. In some, however, many of the indications were wanting, as in certain *Leucosiæ* for example; but in this case, the shell is altogether smooth, and no other furrow indicated divisions which did not correspond with those which we have mentioned.

In some others, the surface of the shell is, on the contrary, marked with an infinity of furrows, and with numerous asperities (*Cancer variolosus*, and *C. incisus*); but the principal divisions have always the same arrangement.

We have found it convenient to give the name of Regions to the different parts of the shell which cover the internal organs, and to distinguish these

regions by particular designations, which bear reference to the relations existing between them and the organs, thus:

The *gastric region* (région stomacale), or that which covers the stomach, is median, or anterior, fig. 2, 1.1.

The *genital region* is median, and situated immediately behind the gastric, 2.2.

The *cardiac region* (région cardiale) is median, and placed behind the genital, 3.

The *hepatic regions* are three in number; two *anterior*, situated one on each side of the gastric, and before the branchial, 6.6; a *posterior* median, placed between the cardiac and the posterior edge of the shell, 4.

The *branchial regions*, two in number, one on each side, are placed between the cardiac and genital regions on one hand, and the lateral edges of the shell on the other, 5.5.

Desmarest describes, according to the plan just detailed, twenty genera, and a considerable number of species from different parts of Europe, Asia, and Africa. Many species occur in Great Britain, but principally in England, where they appear in the chalk formation, and also in the plastic clay of Sheppey.

In Plate CVI. we have given, from Brongniart, representations of a *Limulus* and of a *Cancer*, both of them genera of the Crustacea.]

2. *Trilobites.*

Upwards of an hundred years ago, there was found in England, near to Dudley, in beds of limestone, organic bodies of a very singular form, and different from all the petrifactions which had been previously seen, as well as from every organized body known to exist at the surface of the earth. There was no hesitation, however, in referring them to the animal kingdom; but for a long time it could not be determined to what class they belonged; and Linnæus himself, on placing them with the insects, found their form to be so very different from that of the animals of this class, that he gave to the particular species which he has described the name of *Entomolithus paradoxus.*

Notwithstanding the considerable differences which exist between many of the bodies to which the name of *Entomolites* was at first given, and afterwards that of *Trilobites*, we nevertheless discover between them points of resemblance sufficient to characterize a very natural family.

Their body, as in the greater number of insects and in some crustacea, may be divided transversely into three principal parts. But the principal general characteristic, and what essentially distinguishes them from all known animals, is their longitudinal division into three parts, or lobes, by two deep furrows parallel to the axis of the body; this remarkable structure has excited the attention of all observers. At first the tails were only observed, and from their being considered as shells, the name of *Concha triloba* was given them. Afterwards this designation was transferred to the entire animals, by naming them *Trilobites*, a denomination first given by Knorr, and afterwards employed in a systematic manner by Brünnich and Blumenbach.

The *Trilobites* appear to form a distinct family in the great division of animals named articulated, which may be included in the class Crustacea. It exhibits the following characters:

Their body, as Brongniart remarks, is divided into three parts, which are more or less distinct; the anterior part, which is named the *scutum* (bouclier), (the head, Walch, &c.), appears to present the union of what, in insects, is generally called the head and thorax; the middle part of the body, which is divided by very distinct transverse articulations, may be considered as the *abdomen*, or trunk of Walch, Brünnich, Wahlenberg, or the union of the belly and back; the posterior part, often distinctly separated from the middle division, though sometimes nearly blended with it, and which is divided by less distinct articulations, or transverse folds, may be called the *post-abdomen*. The name of *tail* has been universally applied to it by naturalists, from its analogy with the part in crustacea, to which the same name is given with equal impropriety; it is traversed by the intestinal canal, but as there is, besides this part, a true tail, it would be improper to allow the name to remain. At the extremity of this prolongation of the abdomen, we find, in many species, an elongated appendage of a coriaceous, or crustaceous nature, either without articulations, as in the limulæ, or composed of several plates arranged in the form of a fan, as in the lobsters; this appendicular part, which does not contain any viscus, should bear the name of *tail*.

These two abdomens are divided longitudinally in all the trilobites by two deep grooves, into three longitudinal parts, or lobes, of unequal breadth; the middle one is generally the narrowest and the most distinctly articulated; the lateral ones, which are broader, even sometimes extend under the form of nearly membranous expansions, which appear to be supported by hard and costiform sides, or appendages, proceeding from the abdomen and the post-abdomen. We shall follow M. Audouin in giving the name of sides (or ilia, or latera) *(flancs)* to these lobes, or lateral parts: we have said that this forms the essential character of the trilobites; it is never wanting in any species, and does not occur so distinctly marked in any known living animal.

The scutum (bouclier) is always divided into three more or less distinct parts; a middle one, which, by Walch, is named the *frons* (front), and two lateral ones which may retain the name of *cheeks* (joues), employed by the same author.

We observe upon this frons, or middle part of the scutum, two or more tubercles; and, often upon the two lateral parts, two other projecting tubercles very different from the first, which have been compared to eyes.

The similarity of these parts, in regard to position, general form, and reticular structure, to the reticulated eyes of insects, and especially of the crustacea, scarcely leaves any doubt regarding the analogy which may be established between these tubercles and eyes. The articulations of the abdomen and post-abdomen are sometimes prolonged laterally into projecting appendages.

Sometimes the tail does not exist at all, sometimes

it is formed of a membrane which terminates in a point, or with a crustaceous subulate appendage.

Lastly, no naturalists have ever seen any thing which could be compared to antennæ or feet.

The trilobites are all marine animals; their constant association in the same rocks with shells and other marine productions can leave no doubt on this point. It would appear that they have been capable of multiplying prodigiously, judging from the manner in which certain formations are crowded with them, insomuch that these rocks appear to be entirely composed of them.

The following are the generic names and characters given to these fossil animals by Desmarest:—

Genus I.—Calymene. (That is, obscure or hid.)

Body, contractile, nearly semicylindrical.

Scutum, having several tubercles or folds, *two reticulated oculiform tubercles.*

Abdomen and *post-abdomen*, entire at the margin, the abdomen divided into twelve or fourteen joints.

Point of the *tail* prolonged.

C. Blumenbachii. Dudley Fossil. Auct.

Clypeo rotundato, tuberculis sex distinctis in fronte; oculis in genis eminentissimis; corpora tuberculata.

Abundant at Dudley in Worcestershire. Plate CVI. Three other species are described by Brongniart, and two of these are figured in Plate CVI.

Genus II.—Asaphus. (That is, difficult to determine.)

Body broad and pretty flat; middle lobe projecting, and very distinct.

Sides, or lateral lobes, each twice the breadth of the middle lobe.

Submembranous *expansions* extending the arches of the lateral lobes.

Scutum semicircular, with two *reticulated oculiform tubercles.*

Abdomen divided into eight or twelve joints.

A. Debuchii.

Corpore ovato, antice obtuso: pars caudæ membranacea ad marginem longitudinaliter striata. Plate CVI.

Is one of the species found in Wales. Four other species described by Brongniart, and one of these the A. Cornigerus, is figured in Plate CVI.

Genus III.—Ogygia. (That is, of the greatest antiquity.)

Body much depressed, in the form of an elongated ellipse, not contractile.

Scutum marginate; a shallow longitudinal groove proceeding from its anterior extremity.

No other tubercles than the oculiform ones.

Oculiform protuberances little protruded, not reticulated; posterior angles of the scutum prolonged into a point.

Longitudinal lobes little protruded.

Abdomen with eight articulations.

Two species of this genus, but none of them British, described by Brongniart.

Genus IV.—Paradoxides.

Body depressed, not contractile.

Sides much broader than the middle lobe.

Scutum nearly semicircular; three oblique wrinkles on the middle lobe.

No *oculiform tubercles.*

Abdomen with twelve articulations.

Arches of the abdominal and post-abdominal *sides* more or less prolonged beyond the membrane which sustains them.

Five species, no British, described; and one of these, the P. spinulosus, is figured in Plate CVI. The fossils described by Linnæus under the name *Entomolithus paradoxus* belong to this genus.

Genus V.—Agnostus. (That is to say, unknown.)

Body ellipsoidal, semicylindrical.

Scutum and *sides* with the edges a little elevated.

Middle lobe presenting only two transverse divisions, each of a single piece.

Two glandular tubercles at the anterior part of the body.

Of this genus but one species, and that found in Sweden.

CLASS VI.—Insecta.

From their perishable nature, the animals of this class rarely occur in a fossil state; and when they do appear, they are generally very imperfect. Supposed larvæ of the genera *Libellula* and *Ephemera* occur in the marl slate of Œningen and Pappenheim; and the elytra of coleopterous insects in the Stonesfield slate. Insects well preserved, and of extinct species, occur in amber. Schweigger describes a piece of amber containing a perfect scorpion, but different from the common species of that genus. The ants inclosed in amber appear to be the same with the present species; so that we have the same arrangement in this substance as in rock formations, viz. known and unknown species together.

CLASS VII.—Mollusca.

Fossil Shells.

Fossil shells are amongst the most abundant of the organic remains met with in the strata of which our globe is composed. They exhibit not only great variety in form, but also in magnitude, having a range from the colossal ammonite, several feet in diameter, to the microscopic nautili, and other shells of the same description. They are divided into *univalve*, or those composed of one valve or piece, *bivalve*, with two valves, and *multivalve*, with more than two valves.

1. *Univalve Fossil Shells.*

These univalve shells are again divided into those with one chamber, termed *unilocular*, as the common patella or limpet; and those with several chambers, named *multilocular*, as the nautilus. Upwards

of seventy genera of unilocular shells occur in a fossil state, and many of these include numerous species. The multilocular genera are not so numerous, their number amounting to about twenty-two, but their internal structure is so interesting as to deserve from us some notice. The nautilus, which is one of the best known of these, like all the other genera of this division, has its shell formed into a number of chambers, divided by a perforated septum. The animal which inhabits it, and which is of the sepia or cuttle-fish tribe, resides in the largest and last formed chamber; an elastic tube (siphunculus) proceeds from the animal, and passes through the perforation in the septa and the different chambers, and terminates in the first or smallest. It is conjectured that part of the shell is enveloped by the animal, independent of the connection it has with it by means of the siphunculus. The tube is membranous, and it is probable that it is dilatable and compressible, so as to be capable of rendering the animal buoyant or otherwise at pleasure, as the air-bladder does in fishes. The cells or chambers seem to answer no other purpose than that of containing air, as the animal leaves the last formed one in succession as it forms a new one, keeping up with them no other communication than what is preserved by the siphunculus. Thus, as the animal increases in size and occupies a new chamber, the last in order, and, in the same way, all the preceding ones, are left empty, so that the gravity of the shell is not much more than that of the water of the sea, and hence the addition of a small portion of air, by means of the siphunculus, may render it buoyant, and the expansion of the air, and probably the addition of water, may cause it to sink. Of these nautili some are known to live in the present waters of the globe, but are of rare occurrence, while the fossil species are numerous and abundant. Hence has arisen a question as to the cause of the great disproportion between the number of fossil and of recent shells of this tribe. Some are of opinion that the fossil genera have become extinct, while others maintain that they still live at the bottom of the sea, out of the reach of our observation. But the structure of the shell, as already explained, proves that so far from their inhabitants having been destined to live always at the bottom of the sea, they possess the power of rising up to and remaining at the surface of the sea. Supposing them still to live, they would occasionally, as the present nautilus, be seen at the surface; but not a single instance being known of a shell of these genera having been thus seen, their existence may be reasonably doubted.—(Parkinson's *Introduction.*)

Ammonites.—This is another tribe of multilocular fossil shells, remarkable not only for its beauty and variety, but also on account of its vast abundance and wide distribution in the mineral kingdom. They are the petrified serpents of the vulgar; by some considered as the original type of the volutes of architecture, and have also an interesting mythological meaning. Three hundred different species have been described.

Nummulites.—Another of the concamerated fossil genera, of a discoidal form, and which has been confounded with seeds. It is so very abundant, that sometimes whole tracks of country are principally composed of it. The pyramids of Egypt are partly built of a limestone almost entirely made up of nummulites. Our limits will not allow of any details in regard to the Orthoceratite, Belemnite, Bacculite, and other genera of this remarkable division, which, in general character and economy, agree with the nautilus, already particularly noticed.

2. *Bivalve and Multivalve Fossil Shells.*

The bivalve fossil shells are so numerous and varied in their forms, that we must refer for descriptions of them to the numerous treatises and works on fossil conchology. The multivalves are of comparatively rare occurrence.

CLASS VIII.—RADIARIA.

Echinius, or Sea Urchin Family.

This extensive division of the echinodermata exhibits great variety in form, and although not met with in the older secondary rocks, is abundant in several of the newer. Some of the species resemble those at present met with in our seas, but none of them, as far as we know, are identical with the recent ones.

2. *Asterias, or Sea Star Family.*

The animals of this series, from the delicacy and frailness of their structure, speedily decay, and hence are rarely met with in a fossil state.

3. *Crinoidea, or Encrinite Family.*

The animals of this order appear, from their internal structure and external form, to belong to a series allied to the Radiaria, and therefore cannot be arranged with the simple class of polypi. They abound in many strata, and in vast abundance, but very rarely in a living state,—a fact which shows the great difference between the animal world of the former and present period. Blumenbach first conjectured their affinity to the Radiaria; Schweigger describes them as pediculated and fixed asteriæ; and Miller, in his late excellent work on the Crinoidea, has removed every doubt as to their true place in the system. All the Entrochites and Encrinites of authors belong to this family.

CLASS IX.—POLYPI.

Under this head we include all the different kinds of simple animals named polypi, with their coverings, termed *polyparia.* All the corals popularly so called are polyparia of this class, and many of these occur in a fossil state, as will appear from the following enumeration:—*Astrea*, some species fossil. *Porites*, none fossil. *Madrepora*, few fossil. *Explanaria*, none fossil. *Hydnophoræ*, some fossil. *Meandrina*, some fossil. *Agaricia*, some fossil. *Pavonia*, none fossil. *Fungia*, some fossil. *Cyclolites*, entirely fossil. *Turbinolia*, entirely fossil. *Caryophyllia*, several fossil. *Favosites*, a fossil genus. *Orbulites*, some fossil. *Alveolites*, nearly all fossil. *Flustra* and *Echara*, sometimes fossil. *Gorgonia* and *Antipathes*, not fossil. *Corallina*, not fossil. *Corallium*, rarely fossil.

The most simple of all the animal productions

hitherto found in a fossil state are the alcyoniums and sponges.

The *alcyonia* in the fresh state are nearly as soft as sponge, but have stellular openings on the surface, through which polypi project. They occur sometimes fossil, and frequently in flint.

Sponges are composed of horny fibres connected together by means of an animal jelly, but hitherto no distinct polypi have been detected in them. They occur in a fossil state, and are abundant in the flint of the chalk formation, and in the chalk itself.

II. Fossil Remains of Plants.

Casts and Impressions of Trees and Ferns.

Vegetable remains occur in great abundance, and in considerable variety, in different formations, particularly in the coal formation. In some coal mines they appear well preserved, and thus afford many facilities for the determination of their characters; whilst in others they are so much changed, as to render it nearly impossible to make out the classes and orders to which they belong. In Plates CVII. CVIII. we have given representations of several casts and impressions of the fossil vegetables met with in our coal fields, partly from original drawings, partly from the plates of Sternberg.

1. *Lepidodendron.*—Stem squamous, the scales in perfect specimens, with attached leaves, which are arranged in a spiral manner around the stem. Specimens of four species are represented by fig. 1, 2, 3, Plate CVII., and fig. 7, Plate CVIII., and all of them from the coal formation of the river district of the Forth. Mr Allan, in the *Transactions of the Royal Society of Edinburgh*, has given a figure of a Lepidodendron, with several circular flowers.

2. *Variolaria.*—Stem scutelar, or verrucose, and the centre of the scutæ affording a point of attachment to leaves. This tribe bears some resemblance to arborescent Euphorbia, and to some Cacti. In Plate CVIII., fig. 8, is a drawing of the Variolaria ficoides, with attached leaves. Fig. 4, Plate CVII., is another specimen without leaves, and both from our neighbouring coal fields.

3. *Calamitæ,* so named from their general resemblance to the calamitæ of the ancients. One species is represented by fig. 5, Plate CVII. Fig. 9, Plate CVIII., is another figure of the same genus, but probably a different species.

4. *Syringodendron.*—Of this tribe, one species is figured, fig. 6, Plate CVII.

5. *Rhytidolepis*—Is so named on account of the thick wrinkles with which the back is marked. In coal formation, England. Fig. 7, Plate CVII.

6. *Flabellaria.*—A tribe which resembles the palms, fig. 8, Plate CVII., F. borassifolia, from the coal formation near Burntisland.

7. *Noeggerathia.*—Fig. 3, Plate CVIII. A representation of one of the species of this fossil genus.

8. *Rotularia.*—So named from its resemblance in form to a wheel. Appears to be a cryptogamous plant, probably peculiar to marshy places or water and forms a particular genus. Fig. 6, Plate CVIII., is one of the species from the coal formation.

9. *Schlotheimia.*—Stem jointed, contracted at the joints, leaves verticillated. Fig. 1, Plate CVIII., S. tenuifolia; leaves sessile, awl-shaped, and rigid. Is the hippuris of some authors. From the coal formation near Burntisland.

10. *Annularia.*—Leaves disposed in a vertcillate manner, and inserted in a ring which surrounds the stem. Fig. 2, Plate CVIII., is A. spinulosa from the coal formation.

11. *Osmunda gigantea.*—Fig. 5, Plate CVIII. Occurs in the bituminous shale of the coal formation near Burntisland. The species figured differs from any of the recent species. It is indeed very difficult, in general, to form an opinion as to the ferns found in rocks; for the leaves of ferns of the present creation, even of different genera, are so alike, that they are easily confounded, when we have not an opportunity of examining their seeds, and particularly when we do not attend to the nicer distinctions known to the experienced botanist. How, then, can we determine in a satisfactory manner the impressions in rocks where the seeds are so rarely visible, and the parts so often altered? Smith, Brown, Link, and other eminent botanists, on examining these impressions in slate clay and bituminous shale, thought some resembled a Pteris, another a Dicksonia, others Polypodium, Adiantum, Osmunda; and in all these cases, the individuals they most resembled were natives of tropical climates,—but not a single instance occurred of an impression of any known and recent species. *

2. Leaves of Plants.

Impressions of leaves occur in rocks of different descriptions. Fig. 4, Plate CVIII., is the representation of a leaf of a tree, intermediate between a Platanus and Lyriodendrum. Some impressions resemble Spiræa, others the Tilia Europea, Betula alnus, Betula fruticosa, Salix caprea, Acer pseudo-platanus, Populus nigra, Acer campestre, Rhamnus frangula, Salix myrsinites. These impressions are found in some of the rocks of the Paris formation. Leaves are also sometimes found in amber, and some are of opinion that these belong to the Aloexylon agallachum, and the amber itself is conjectured to be an exudation from that tree.

3. Impressions of Flowers.

Beautiful specimens of aster-like flowers are sometimes met with in a lepidodrendous tree in the coal formation near to Edinburgh; and one of these, as already mentioned, has been figured in the *Transactions of the Royal Society of Edinburgh.*

Schlotheim describes the impressions of a flower

* Schlotheim has lately published descriptions and figures of impressions of sea plants, fuci, found in a coal formation connected with a limestone which rests upon the new red sandstone formation. Similar impressions occur in the coal field near Burntisland.

of a ranunculus from a metalliferous bed near Frankenberg in Hessia; also impressions of an aquatic Ranunculus or Trollius in the limestone of Oeningen. In Blumenbach's *Spec. Arch. Tellur.* and in Karg's *Essays*, there are observations on this subject.

4. *Fossil Seeds and Fruits.*

Fossil seeds and fruits of plants occur in different formations, but usually in such a state as renders it nearly impossible to determine the tribes to which they belong. Faujas St Fond found fossil fruits in the brown coal of Liblar, which, he said, bore a strong resemblance to areca nuts; an opinion in which he was not supported by the after examinations of Jussieu, Desfontaines, Lamarck, and Thouin. They probably belong to some palm. The fossil seeds that occur in bituminous wood, in which amber also is found, cannot be referred to any known plants. In the Island of Sheppey there are accumulations of seeds, some of which are like those of the palm, others the chesnut, cocoa, but none identical with any of these.

5. *Plants in Calcedony, Siliceous Sinter, and Calc-Tuff.*

The early observations of Daubenton, and the later ingenious investigations of Dr Macculloch, seem to prove the existence of various cryptogamic plants in calcedony, particularly in that variety named *mocha stone*. The included vegetables are referred to the tribes Jungermannia and Hypnum of botanists. The siliceous sinter of Iceland, sometimes confounded with calcedony, we find also to contain occasionally plants of different descriptions. Calc-tuff, in some districts, as at Burgtonna, contains well preserved specimens of the Chara vulgaris, and Ch. hispida. Confervæ have also been found in a preserved state in compact calc-tuff. Some of the gyrogonites of Lamarck, found in calc-tuff, are certainly seeds of the chara tribe.

6. *Petrified Woods.*

Trunks, branches, and roots of trees occur in rocks of different kinds, or even loose, more or less impregnated or petrified with mineral matter. The structure and external form are sometimes well preserved, and in other cases both are nearly obliterated. Some of these, belonging to the palm tribe, are therefore monocotyldonous; others, and the greater number, present concentric rings and other internal arrangements which characterise dicotolydonous trees. Hitherto no accurate descriptions have been published of the internal structure of these petrifactions, and consequently the names given to them are not to be depended on. Thus it is said that oak, birch, pine, box, elm, willow, hazel, ash, occur petrified in the form of wood-stone and wood-opal; but our own experience does not go to confirm these determinations.

II.—STATE OR CONDITION OF FOSSIL ORGANIC REMAINS.

Fossil organic remains occur either unchanged, or more or less altered from their original state or condition, by the removal of some of their constituent parts, their bituminisation, or owing to impregnation with various mineral substances. Shells, bones, teeth, vegetables, of various descriptions, in some alluvial soils, are scarcely at all altered, and remains of quadrupeds have been found well preserved in ice in polar countries; and in peat-mosses, human bodies remain uncorrupted for a long series of years. Shells are sometimes found in a nearly unaltered state in solid rocks, as limestone. The beautiful fire marble of Carinthia contains unaltered shells of ammonite, with their pearly lustre, and rich tints of the most beautiful colours. Shells and bones occur in other alluvial strata, more or less bleached, being dry and fragile, owing to the removal of a portion of their animal matter. In fossil fishes, sometimes not only the bones, but also the soft parts, and even the scales, occur more or less perfectly preserved. Fossil vegetables occur, either nearly unaltered, or more or less bituminised or carbonised, in alluvial strata, also in the brown-coal formation, and in some sandstones. In other cases, the animals or vegetables have disappeared, and only their casts, or impressions, remain to attest their former presence. This change is more frequent with vegetables than animals. In particular situations, the organic body, whether plant or animal, is simply coated, or incrusted, with the mineral matter, and but slightly impregnated with it. The incrusting matter is most frequently calc-tuff and calc-sinter, less frequently volcanic tuff. But the most durable state of fossil organic remains is the *petrified*, when they are more or less completely impregnated with mineral matter.

I. Petrified Vegetables.

Wood Petrified with Hornstone.—Trunks, branches, and roots of trees and shrubs are sometimes impregnated with hornstone, forming what is called wood-stone, or ligneous hornstone, and this is one of the most frequent of the petrified woods. The wood appears, in some cases, to have been in a rotten state when petrified, and such varieties appear light coloured and shivery; in other cases, it appears first to have been bituminised, so that it is both bituminous and siliceous together, in which case it is of a dark brown or black colour, and of a more compact texture. In our Cabinet, we have several specimens to show the combination of siliceous matter and bituminous wood in its different stages of bituminisation. Lastly, in other cases, the wood appears to have undergone no change, and then, the wood, or at least part of the ligneous matter, remains in the petrifaction, while, in others, the whole has disappeared, leaving nothing but its form behind. It is probable, however, that many wood-stones, in collections, are not real petrifactions, but portions of trees in which a great secretion of silica has taken place. In the Museum of the University of Edinburgh, there is a large mass of wood-stone, said to have been obtained from the centre of the trunk of a teak tree, which may be viewed as a portion of the wood highly im-

pregnated with silica by the living powers of the tree. *

2. *Calcedonic Wood and Jasper Wood.*—In some cases the wood is petrified with calcedony, and in others with jasper; the first has usually a yellowish white colour, and resembles decayed wood, while the latter exhibits great variety of colours. In some rare varieties of Heliotrope a fibrous and probably vegetable structure occurs.

3. *Opaline Wood.*—Wood, when impregnated with opal, forms the most beautiful variety of petrified wood. It is distinguished from the others by resinous lustre, conchoidal fracture, inferior hardness, and lower specific gravity. Hungary is the chief country of this beautiful fossil remain.

4. *Calcareous Wood.*—Wood is sometimes more or less completely petrified with carbonate of lime, in the form of calcareous spar or of limestone. In some cases the wood appears to have been bituminous before petrifaction, in others rotten, and in some not altered. It occurs in alluvial soil and in various limestones in different parts of England.

5. *Aluminous Wood.*—Some woods are petrified with aluminous matter, but generally along with it there is a considerable intermixture of iron pyrites.

6. *Wood petrified with Iron Pyrites.*—Fossil wood of this description soon decays on exposure to the influence of the weather. Seeds are sometimes in this state, as is the case in the Island of Sheppey.

7. *Wood and other Parts of Trees and Plants petrified with Carbonate and Hydrocarbonate of Iron.*—Wood and fossil vegetables in this state are not of rare occurrence, and are the most indestructible of the woods impregnated with ores.

8. *Wood impregnated with Copper Pyrites.*—This variety of mineralized wood generally contains, besides pyrites, blue and green malachite, which stains it with their beautiful colours.

9. *Wood impregnated with Galena or Lead-Glance.*—Some specimens of this description occur in old mines, thus proving the comparative newness of their formation, while others of a more ancient date occur in brown coal.

2. Petrified Animal Remains.

The remains of quadrupeds, birds, and amphibious animals are seldom impregnated with mineral matter, and when this takes place, it is generally their harder parts which are petrified. The horns of deer are sometimes impregnated with clay iron ore, and bones of quadrupeds occur penetrated with lead-glance and iron pyrites, and have superimposed crystals of the same minerals. The fossil fishes in the bituminous marl slate of Thuringia are often entirely bituminised, and, according to Werner, the bituminous impregnation of the slate is derived from these fishes. Sometimes the fishes in the marl slate are also impregnated with copper pyrites, and also with lead-glance and iron pyrites. Crustaceous animals are petrified with calcareous spar, or with iron pyrites. The Echini, or Sea Urchins, are petrified with calcareous spar, with flint, and seldom with iron pyrites. The various tribes of shells and corals are often petrified with calcareous spar, less frequently with clay iron ore, and rarely with flint or calcedony, and with sulphur. And lastly, the Alcyonia and Sponges, the lowest of the animal world met with in a fossil state, are usually penetrated or impregnated with flint.

III.—GEOGNOSTICAL SITUATIONS OF FOSSIL ORGANIC REMAINS.

When fossil organic remains first engaged the particular attention of naturalists, it was believed that they were irregularly distributed throughout the different formations of which the crust of the earth is composed, and that the whole had been deposited from the waters of the Deluge. It was soon, however, ascertained, that some rock formations never contain petrifactions; a fact which gave rise to the opinion, that fossil organic remains were confined to one set of rocks, the secondary, in which they were jumbled together in an irregular manner, while they were entirely wanting in the formations of the primitive class. The more accurate investigations of geologists, particularly those of the geognostical school of Werner, not only proved the insufficiency of former views, but gave a new and interesting character to the whole subject. It was shown by these inquiries, 1. That petrifactions, or fossil organic remains, do not occur in primitive rocks, but first appear in rocks of the second, or Transition class. 2. That these organic remains are, in general, more altered, or mineralised, in the older than in the newer formations; so that they appear much changed in transition rocks, and scarcely at all altered in the rocks of the newest, or alluvial class. 3. That these remains are so arranged in the bowels of the earth, that those of the more simple animals and plants appear first, or in the oldest rocks; that in rocks of a middle age, the remains are of animals higher in the zoological and botanical scales; and that in the newest rocks, the fossil organic remains are of the more perfect animals, even reaching to man. † 4. That the fossil organic remains in transition, secondary, and diluvial formations, are in general different from those of the present creation; but that, in the post-diluvial formations, the remains are of recent species of animals and vegetables. 5. And lastly, that although these fossil animals and plants, in general, differ from those of the present world, we observe

* Workmen remark that mahogany, plane tree, and other woods, are sometimes harder than usual; and also, that they occasionally contain grains of sand. The hardness may be partly owing to secreted silica, and the sand would appear to be silica, secreted by the powers of the plant, therefore resembling that in the teak wood, the rush, and the bamboo.

† The terrestrial rock formations, or those which have been formed on the land, are still so imperfectly known, that, in some cases, it is not easy to determine their age in relation to those which have originated under the water of the ocean.

that they approach nearer and nearer, in appearance, to those of the recent tribes the newer the formation in which they are contained ; so that, as already mentioned, in the newest formations there is an absolute identity of character, proving that the fossil species are the same as those of the present creation. A full statement of all the facts on this very interesting subject would extend this article much beyond the limits prescribed ; and, therefore, we must rest satisfied with the following account of the distribution of petrifactions as they occur in different rock formations, particularly as observed in Great Britain.

Primitive rocks, as already mentioned, contain no organic remains, and, therefore, are supposed to have been formed before animals and vegetables were called into existence. They first appear in the rocks of the second great class or the Transition.

I. Fossil Organic Remains in Transition Rocks.

The rocks of this class which afford organic remains are limestone, greywacke, and clay slate ; but of these limestone is that which affords the greatest number and variety. All the remains, nearly, are of animals, and of tribes occupying a comparatively low rank in the zoological scale ; none of them ranging higher than the class Mollusca ; and most of the species, and some of the genera, occur only in the transition series, disappearing entirely in the rocks of the succeeding formations.

The following tribes of corals are met with, and generally in the limestone, *Caryophylkia*, *Tubipora*, *Favosites*, *Astrea*, *Madrepora*, and *Stylina*. The last mentioned genus is, with the exception of one recent species found in the South Sea, entirely fossil, and confined to the transition class. This is one of many instances, of the occurrence of fossil animals along with those of the earliest creation, no traces of which have been seen in any of the subsequent formations, but which are now found in a living state in the seas of the opposite hemisphere. No fossil Echini, or Asteriæ, occur in the rocks of this class, but several tribes of the nearly allied family Crinoidæa are met with, such as the *Cyathcrinites* from Shropshire ; *Platicrinites* in limestone, Dudley ; and *Rhodocrinites*, also at Dudley. The *Trilobite* tribe, so nearly allied to the Crustacea, occurs abundantly in the rocks of this class, but principally in the limestone. When the crustacea begin to appear in the newer formations, the tribolites have disappeared, if not altogether, at least almost so. Fossil shells occur in greater numbers and variety than is generally imagined. Of these the multilocular univalves are the most characteristic in a geognostical sense, and the following are the genera met with, viz. *Ammonites*, *Orthoceratites*, *Nautilites*, and *Conularia*. Unilocular univalves are *Euomphalus*, *Helecites*, *Patellites*, *Buccinites*, and *Bucardites*. Bivalves are *Anomites*, *Terebratulites*, and *Pentamerus*. The vegetable remains are of rare occurrence, and their peculiar characters have not been determined. The corals, orthoceratites, and trilobites are the most characteristic petrifactions of this class.

II. Fossil Organic Remains in Secondary Rocks.

1. *First Sandstone, or Old Red Sandstone.*

Occasionally, remains of plants, shells, and corals, occur in this formation, but hitherto they have not been determined with the requisite accuracy. *

2. *First Secondary Limestone, or Mountain Limestone.*

This formation, which, in a general view, rests upon old red sandstone, and sometimes alternates with the rocks of the coal formation, is more abundant in petrifactions than the transition rocks. Of the tribe of corals, it contains species of the genera *Caryophlylia*, *Turbinolia*, and *Flustra* : of the *unilocular* univalve shells, *Euomphalus*, *Planorbis*, and *Cirrus* : *multilocular* univalve, *Orthoceratites*, *Nautilites*, *Ammonites*, *Ellipsolites*, *Nautellipsites*, *Conularia*, and *Amplexus*. Of the *bivalve* genera, the following are met with, viz. *Productus*, *Pentamerus*, *Spirifer*, *Terebratulites*, *Gryphites*, and *Cardites*. It is worthy of remark, that many of the univalves and some of the bivalves that occur in this and the transition limestone, possess that particular kind of structure, rarely met with in the shells of the present creation, which enabled their inhabitants to rise and sink in the water. The curious structure of Spirifer, and the multilocular arrangement of Productus, Pentamerus, Amplexus, and Conularia, as Mr Parkinson remarks, imparted, in all probability, to their inhabitants, a power of a similar kind. Sowerby mentions a shell resembling the Helix found in mountain limestone ; but Parkinson is of opinion, that it belonged to a distinct genus, and probably possessing the same power as janthina (formerly considered as a helix), that of sinking and rising in the water. Hitherto, no remains of Asteriæ or Echini have been met with in this formation, but the platycrinites of the Crinoid family, is not unfrequent. No true crustacea occur, but several members of the family *Trilobites* are found in the mountain limestone of England and Ireland. Some obscure traces of fossil fishes are rarely met with. As examples of these may be mentioned the supposed spinous radii of a Balistes, and imperfect remains of what resembled the snout of the *Xiphias*, or sword-fish.

3. *Coal Formation.*

This formation is principally remarkable on account of the numerous fossil remains of plants which it affords. Several of the principal tribes are represented in the plates attached to this article. All the species, and most of the genera belong to plants different from those of the present creation ; many of them, and those the predominating ones, resemble cacti, palms, reeds, and ferns ; thus intimating the general state of the earth's surface when they flourished.

* The petrified woods in old red sandstone are often in the state of woodstone.

The bituminous shale and slate clay sometimes contain *Orthoceratites*, *Terebratulites*, *Ammonites*, and some species of the genera *Lingula* and *Unio*.

4. *Second Secondary Limestone, or Magnesian Limestone.*

The fossil organic remains of the magnesian limestone, which, in the general succession, rests immediately upon the coal formation, have not hitherto been much studied. Some Flustræ and Crinoidæa are mentioned as occurring in it; and also species of the genera *Donax*, *Arca*, *Anomia*, and *Unio*; and lastly, remains of a fish, of the genus *Chælodon*, were found imbedded in this formation near to Sunderland.

The limestones named *Bituminous Marl Slate* and *Zechstein*, are associated with this magnesian limestone, and, therefore, are considered as belonging to the same general formation. The bituminous marl slate often forms the lower part of the series of magnesian limestone, and contains numerous petrified *fishes*; which some naturalists are inclined to consider as principally fresh water species; a few only appearing to them to have been inhabitants of the ocean. In this limestone also there occur remains of an animal of the genus *Monitor*, of the class Amphibia; but petrifactions of vegetables are rarely met with. We sometimes meet with branches of plants analogous to the *Lycopodium*, and more rarely of *ferns*, and of plants allied to the genus *Phalaris*. Amongst these fresh water productions, various remains of marine animals, such as *Gryphites*, *Trilobites*, and *Crinoidæa*, make their appearance.

The *Zechstein* is particularly distinguished by the great abundance of the *Gryphites aculeatus* it contains; *Ferns* and *Lycopodiums* resembling those of the coal formation; and it is said, also remains of *Lepidodendrous plants* are found in it.

5. *Second Sandstone, or New Red Sandstone Formation.*

Very few organic remains have hitherto been found in this formation, and those met with are *fossil trees* and *shells*.

6. *Third Secondary Limestone, including the Lias, and Oolite.*

a. *Lias Limestone.*

This limestone rests on the new red sandstone. It abounds in fossil organic remains, of which the following list contains several of the more interesting:

Corals are of rare occurrence; species of one tribe only, the *Turbinolia*, having been met with. Several species of the genus *Pentacrinite* are met with; and also remains, more or less perfect, of *Echini*. The fossil shells in this rock differ considerably from those of the mountain limestone and other preceding formations; only a few species of some of the multilocular univalves, as *Ammonites*, *Nautilites*, and *Belemnites*, and of the *Terebratulas*, being here discoverable. The fossil shells found in this formation chiefly consist of bivalves of the genera *Ostrea*, *Gryphæa*, *Plagiostoma*, *Plicatula*, *Avicula*, *Mya*, and *Cardita*, with the single univalve shell *Trochus Anglicanus* of Lister, not, perhaps, met with in any of the succeeding strata; a shell of the genus *Helicina*, and the first simple unilocular shell having a turriculated form, met with in a fossil state, being a species of the genus *Melania*. Several species of *crustacea* occur. Spines, teeth, and other parts of *fishes* also occur, but in general in an imperfect state. Bones and palates of *turtle* have been found in this formation; but it is particularly distinguished by its containing remains of two very remarkable extinct genera of oviparous quadrupeds, belonging to the same class with the natural order Lacerta, but yet differing in structure from all the genera at present known to exist, and in such particulars as must have fitted them to live entirely in the sea. These are the animals already mentioned under the names *Ichthyosaurus* and *Plesoisaurus*.

b. *Oolite, &c.*

In the strata above the lias belonging to the oolite, including also the rocks named Cornbrash, Coral Rag, &c. many genera of organic remains are met with, which we shall now enumerate in the usual manner, beginning with those of the lowest or least perfect animals.

1. *Lower Oolite.*—Traces of *Alcyonia*, and the following genera of corals, are met with, viz. *Explanaria*, *Astrea*, *Caryophyllia*, *Fungia*, and *Cyclolites*. The interesting *Crinoide* family affords the Pentacrinites Caput Medusæ, and Subangularis; species, sometimes well preserved, of the genera Conulus, Cidaris, Echinus, and Clypeus of the Echinus family, are met with, and rarely fragments of Crustacea. Shells of the following genera are abundant, viz. *Pecten*, *Ostrea*, *Terebratula*, *Modiola*, *Tellina*, *Unio*, *Lutraria*, *Trigonia*, *Trochus*, *Belemnites*, *Nautilites*, and *Ammonites*. Remains of vertebral animals are of rare occurrence, the only instance known being of vertebræ, supposed to belong to the marine *lacertæ*.

2. *Cornbrash, Stonesfield Slate, Forest Marble,* and *Great Oolite.*—The following is a general enumeration of the organic remains met with in this part of the oolite series, which, in the regular succession, rests on the lower oolite.

Species of *Millepore*, *Tubipore*, *Cyclolite*, and *Caryophyllia*, occur in this part of the oolite series, and the *Encrinital family* appears in considerable variety; species of Echini, and two or three varieties of Crustacea also occur. The fossil shells are of the following genera: *Terebratula*, *Lima*, *Avicula*, *Pecten*, *Ostrea*, *Cardium*, *Trigonia*, *Modiola*, *Serpula*, *Voluta*, *Turbo*, *Turritella*, *Ampullaria*, *Ammonites*, and *Nautilus*. Teeth, vertebræ, and palates of *fish* are met with; and also several species of *Tortoise*. Several oviparous quadrupeds have been found; one is a well characterized *Crocodile*, and remains of a *Megalosaurus*, forty feet long, were found at Stonesfield. But the most singular fact is, the occurrence of bones of a species of Didelphis, or *Opossum*, in the Stonesfield slate. Fragments of *fossil wood* are met with; and the Stonesfield slate exhibits beautiful impressions, chiefly of *ferns* and *reeds*, many of which resemble those of the coal formation.

3. *Coral Rag.*—This limestone lies above the preceding, and is also a member of the Oolite series. It abounds in *corals,*—contains many different species of the tribe *Echinus*, and considerable variety of bivalve and univalve shells, and among the latter are species of *Ammonites*, *Nautilites*, and *Belemnites*. The remains of vertebral animals are rare, and of these the most remarkable are the vertebræ of the *Ichthyosaurus*.

4. *Kimmeridge Clay.*—Under this head we include a series of clay beds, higher in the series than the preceding, but still belonging to the oolite formation. It contains both bivalve and univalve fossil shells, and of these the most characteristic is the *Ostrea deltoidea*. It also contains remains of the *Ichthyosaurus* and bones resembling those of the *whale*.

5. *Portland Oolite.*—The most characteristic shells in this Oolite are the *Ammonites triplicatus*, and *Pecten lamellosus*.

6. *Purbeck Beds.*—This limestone contains beautiful impressions of *fish*; also bones of *turtle*, and heads of *crocodiles*. Its shells have not been well examined.

7. *Third Sandstone Formation, or Green Sand Formation.*

In this formation the organic remains, whether of animals or vegetables, are often in a siliceous state. All the *wood* found in this formation is silicified, but none of it has hitherto been referred to any even of the most general divisions of the botanical system. Numerous silicified *Alcyonia* are met with, and also a good many fossil species of the family *Echinus*. Corals, and also species of the *Crinoid* family, rarely occur. *Shells* occur in vast abundance, and in great variety; but, with the exception of a few teeth of *fish*, no remains of vertebral animals have hitherto been met with.

8. *Fourth Limestone Formation, or Chalk Formation.*

a. *Chalk Marl.*

The lower part of this formation, named *chalk marl*, affords considerable variety of fossil organic remains;—fossil *Corals, Sponges, Echini, Crustacea, Encrinites*, and *bivalve* and *univalve shells;* and of these the most abundant and interesting are those of the multilocular division. The species of the multilocular genus *Hamites* are numerous and abundant, and are highly characteristic of this part of the chalk formation. *Fossil wood* is sometimes met with.

b. *Chalk.*

This formation contains many organic remains of animals, from the sponge to the alligator. The families of *Alcyonium* and *Spongia* occur in great variety of form, but their characters are still much involved in obscurity. *Madrepores* occur, and but little changed from their original state; also several genera of the *Crinoidea*, and the species often in a high state of preservation. Several species of the *Asterias*, or star fish, are described as occurring in chalk; but of all the organic remains, those of the tribe *Echinus* are the most numerous, abundant and characteristic of the formation. Of the fossil shells probably the only genera peculiar to the chalk are the *Crania* and *Magas*. Of the multilocular genera the following are met with; viz. *Ammonites, Scaphites*, and *Belemnites*. The first occurs rarely in the upper chalk; the second only in the lower. The remains of several tribes of fishes are met with, which are alleged to belong to the following genera; viz. *Squalus, Diodon, Balistes, Murœna, Anarhichas, Salmo, Esox*, and *Zeus*. The remains are chiefly different sulcated palates, teeth, detached vertebræ, and irregular masses, with the scales of fishes. The teeth are generally referable to different species of shark or *Squalus;* the bony tongues and palates to different species of *Raia*.

9. *Brown Coal Formation.*

This formation, which rests upon chalk, is almost entirely composed of extinct species of plants; and in some countries, as Switzerland, it is associated with vast accumulations of a conglomerate named *Nagelfluhe*.

10. *Paris Formation.*

Under this head we comprehend all the different secondary rocks newer than the brown coal or chalk formations. In this group of rocks the number and variety of organic remains is great, and in general they are in a higher state of preservation than in the preceding formations, and also approach much nearer to the organic beings of the present creation. The members of this series, as it occurs in England, are as follows, reckoning from below upwards. 1. Plastic clay. 2. London clay. 3. Fresh water formations. 4. Upper marine formations.

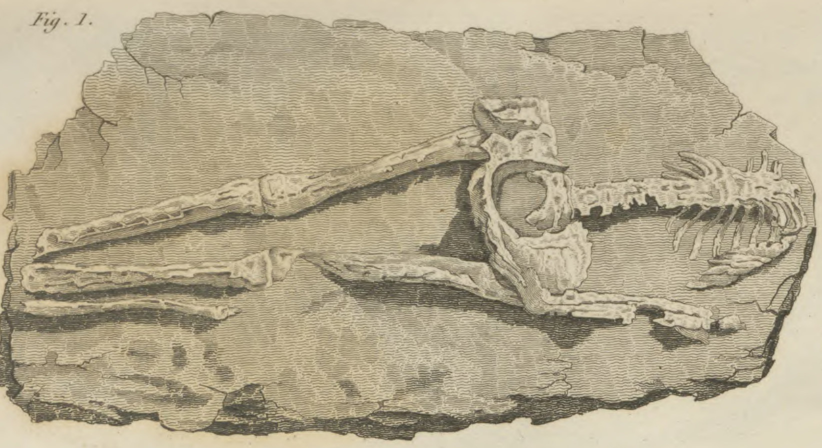
1. *Plastic Clay.*—In this clay, which reposes immediately either on brown coal or chalk, there are *Ostreœ, Cerithiœ, Turritellœ, Cyclades*, &c. together with the teeth of *fish* and portions of *coal*.

2. *London Clay, the Calcaire Grossier of the French.*—Few *corals* occur; the *echinites*, so common in chalk, are very rare in this formation, and very few of the *encrinite* family have yet been discovered. *Crabs* and *lobsters* are frequent; for in the British Museum there are preserved thirty different species of crabs from the London clay in the Island of Sheppey. *Fossil shells* are numerous and well preserved, often retaining nearly the appearance of recent shells. There are but few genera of recent shells that do not occur in this formation, but the species are generally different; on the other hand, few of the extinct genera, so common in the older formations, occur in this. No multilocular or bivalves of complicated structure occur in this clay. About thirty-two genera of bivalves have been found in the more ancient strata; and only five or six new genera have been found in the London clay; but, on the other hand, the more ancient strata have been found to contain only twelve or fourteen genera of simple turbinated univalves, whilst the London clay and its accompanying sands and crag have afforded thirty-two genera of turbinated shells; twenty-five of which, with about sixteen other genera not known to have existed in a mineralised slate, inhabit the present waters of our globe. *Petrified fishes* of great beauty are

FOSSIL ORGANIC REMAINS. PLATE CII.

Fossil Human Skeleton from Guadaloupe

Fig. 1.



Ornithocephalus longirostris. embedded in Limestone.

Fig. 2.

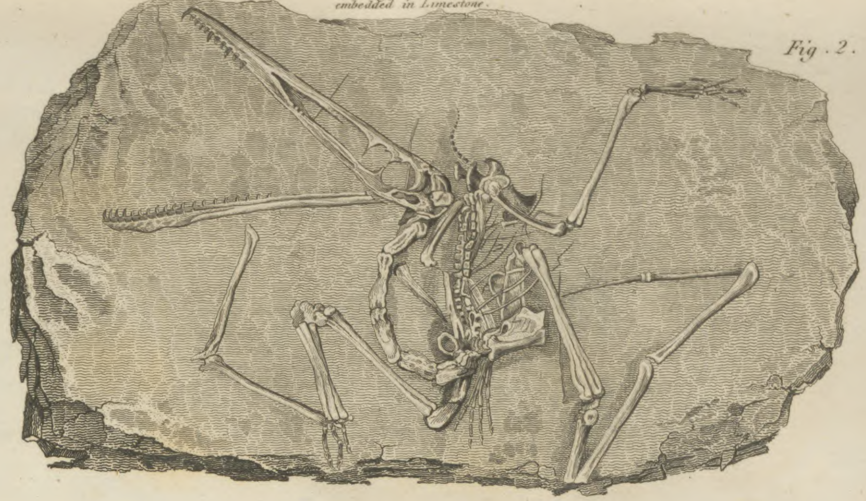


Fig. 3.

Ornithocephalus brevirostris.

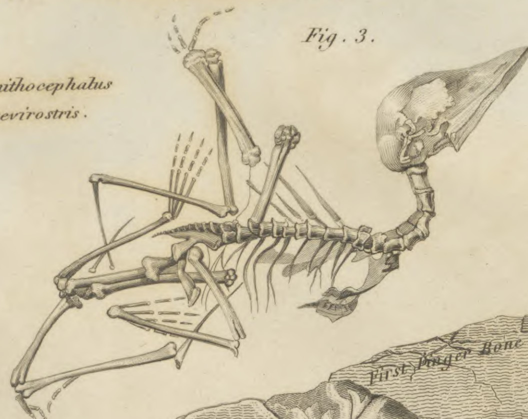


Fig. 4.

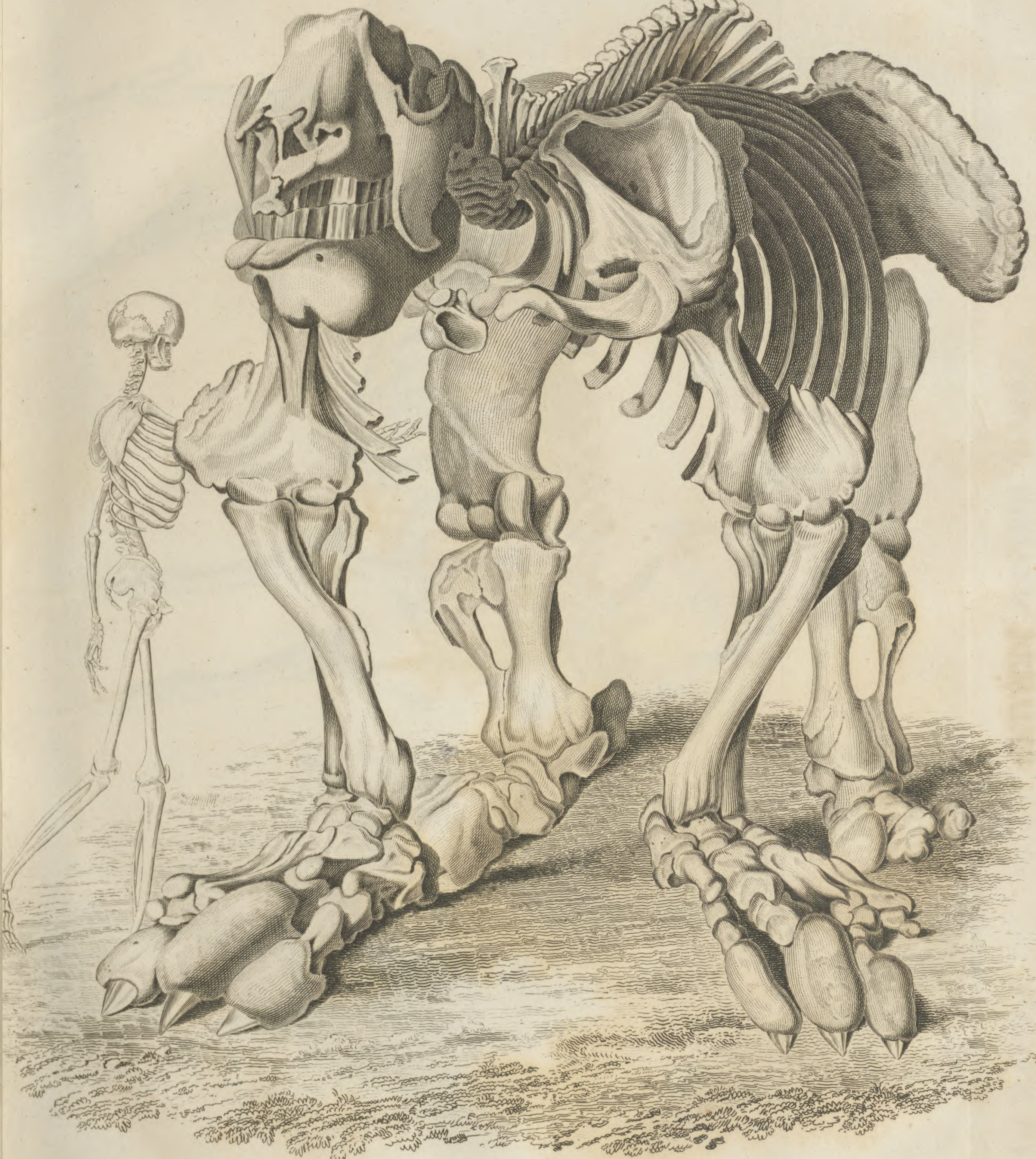
Ornithocephalus brevirostris.

Fig. 5.

Wing & Leg bones of a large Fossil Bat embedded in Limestone of Eichstadt.

Published by A. Constable & Co. Edin.r 1822.

Drawn & Engraved by W.H.Lizars

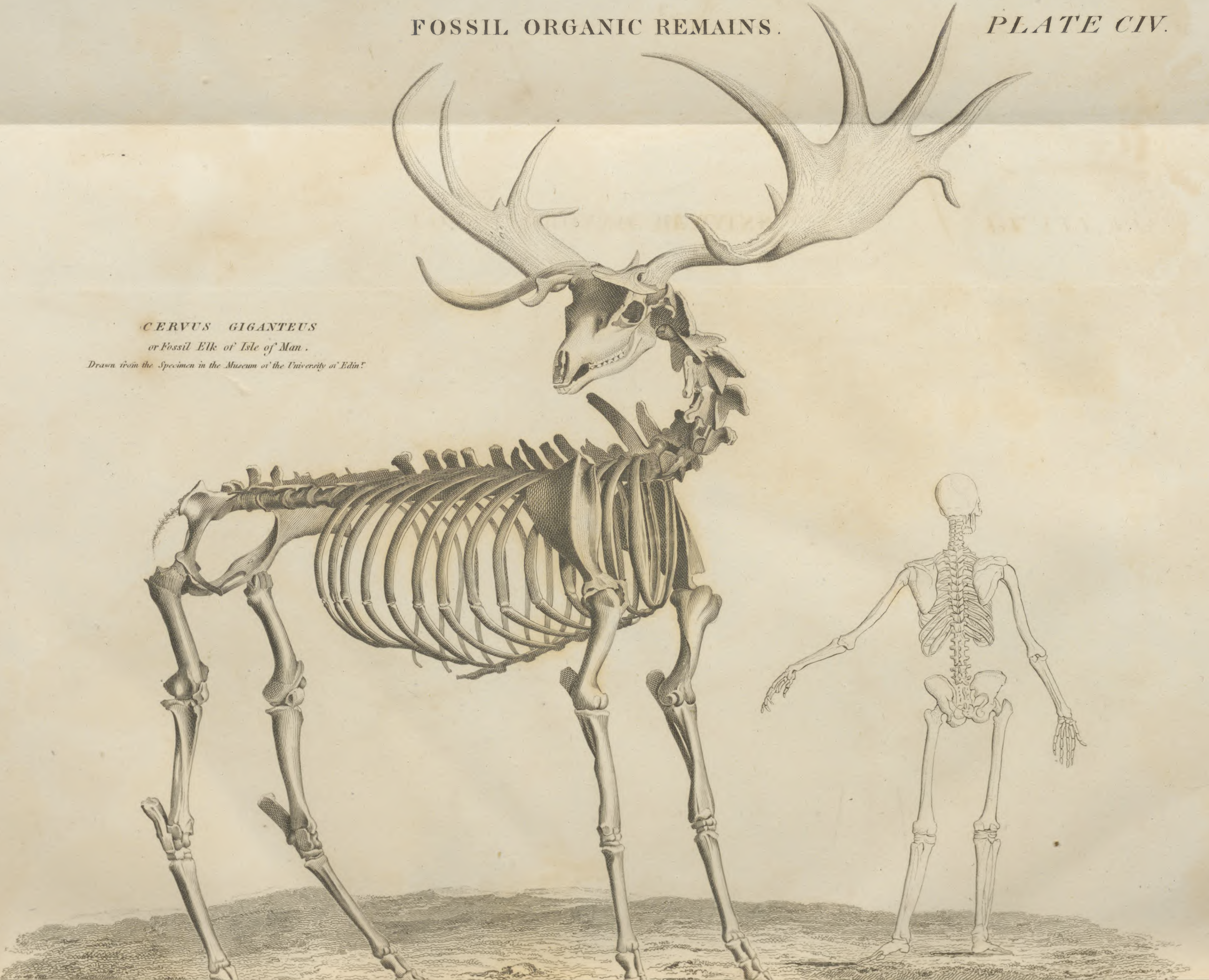


MEGATHERIUM.

Drawn from the Specimen in the Royal Cabinet of Madrid.

Engraved by W. H. Lizars

Published by A. Constable & C^o. Edin^r. 1822.



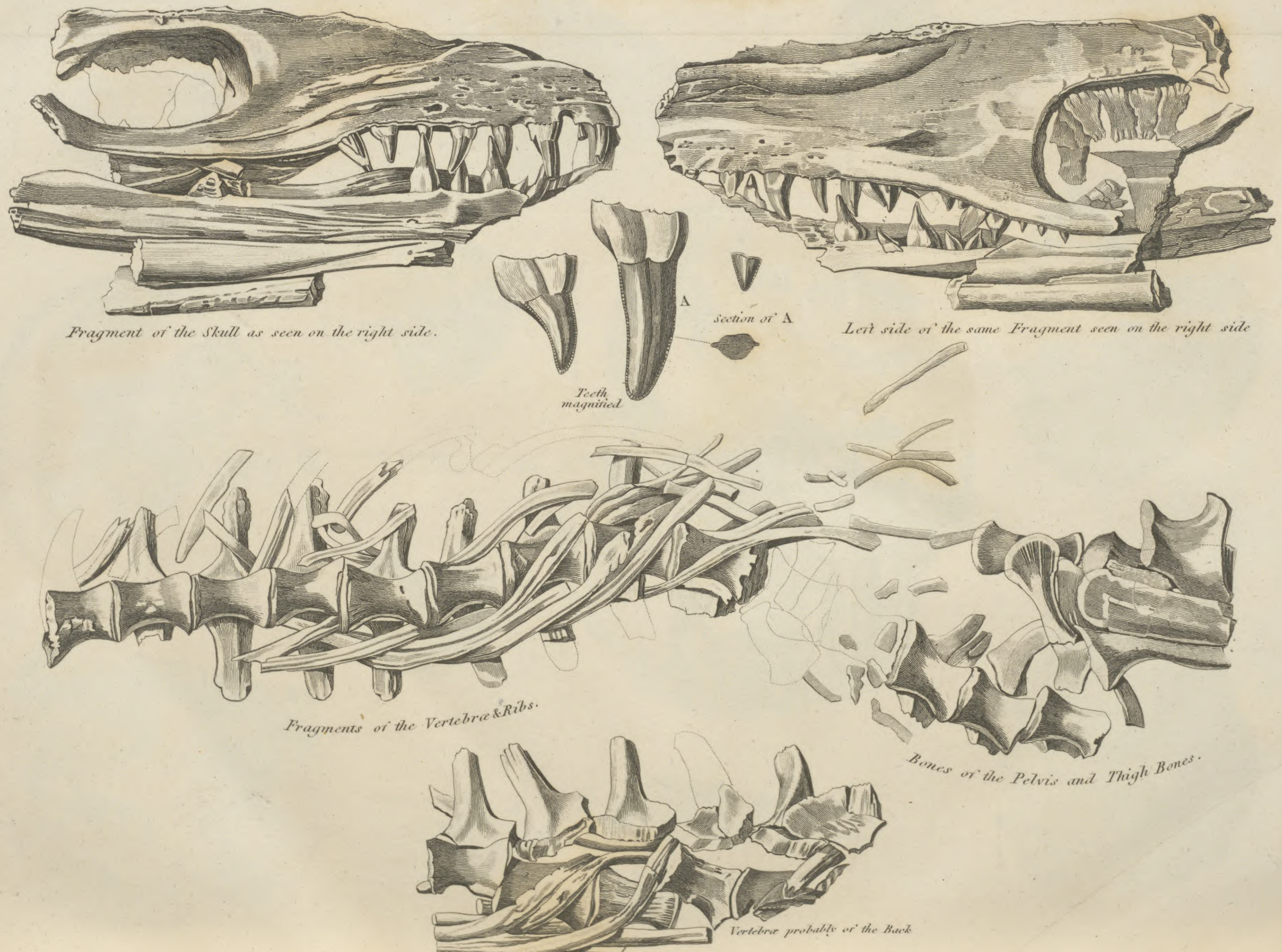
CERVUS GIGANTEUS

or Fossil Elk of Isle of Man.

Drawn from the Specimen in the Museum of the University of Edin.r

FOSSIL ORGANIC REMAINS

PLATE CV.



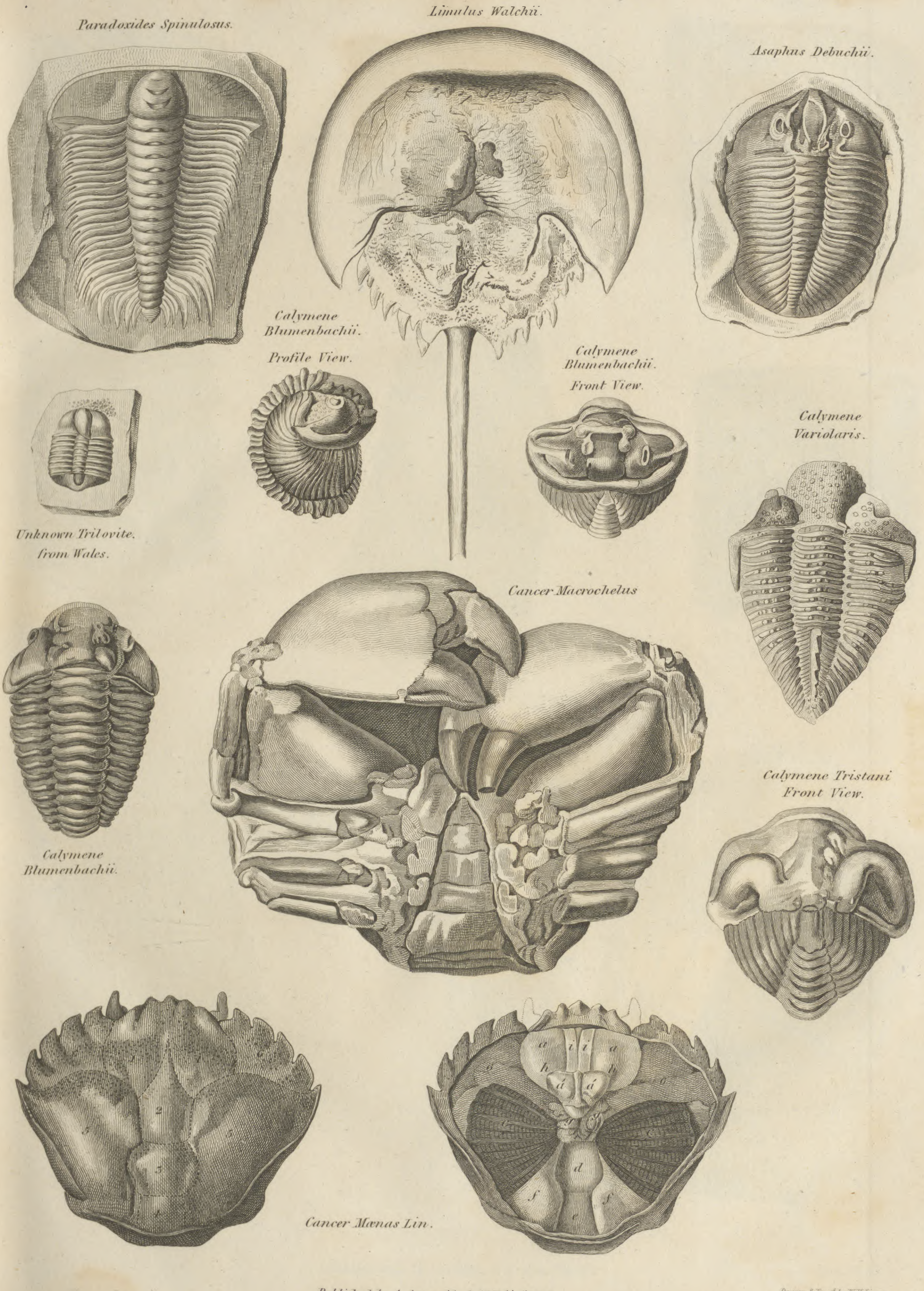


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Fig. 1.

Fig. 2.

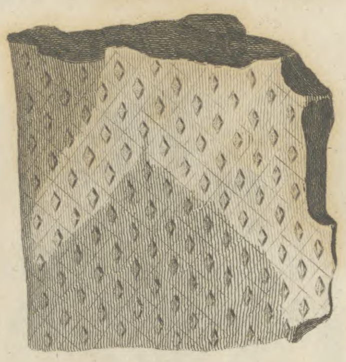
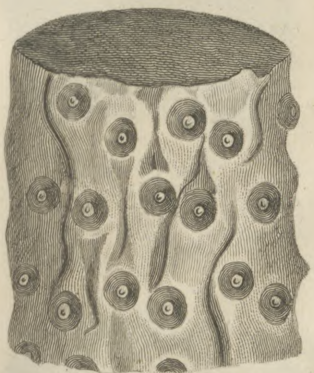


Fig. 3.

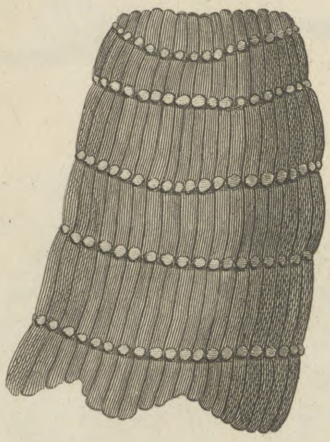
Lepidodendron

Fig. 4.



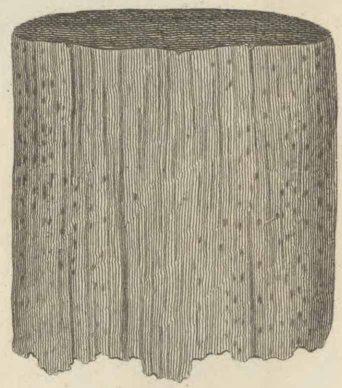
Variolaria ficoides

Fig. 5.



Calamites nodosus

Fig. 6.



Syringodendron

Fig. 7.

Rhytidolepis ocellata

Fig. 8.

Flabellaria borassifolia

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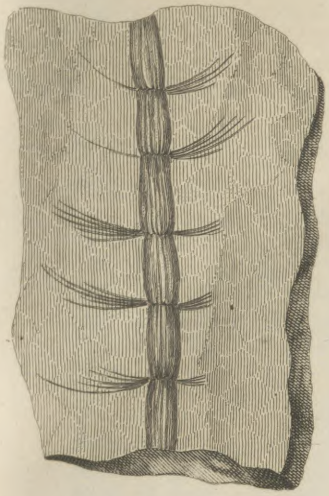
Fig. 1.

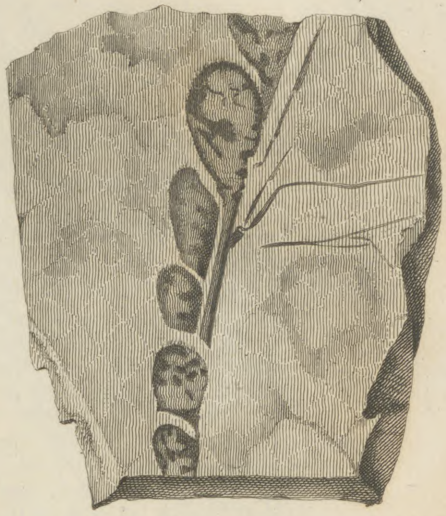


Schlotheimia tenuifolia

Fig. 2.

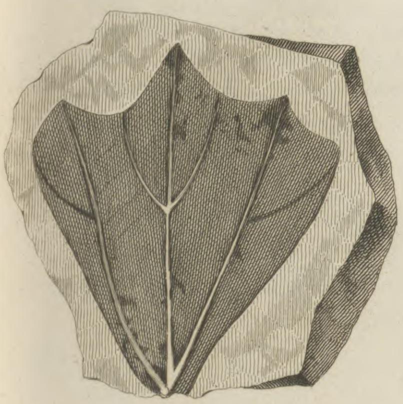
Annularia. spinulosa

Fig. 3.



Noeggerathia. foliosa

Fig. 4.

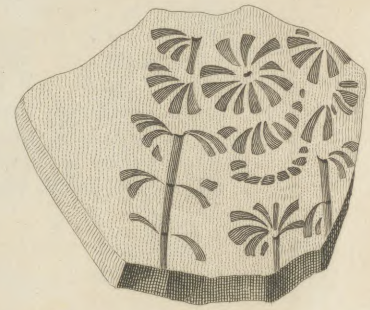


Between Platanus & Lyriodendron

Fig. 5.

Osmunda. gigantea

Fig. 6.

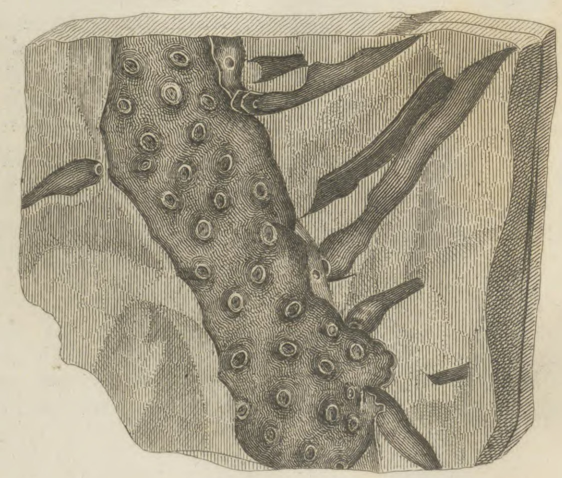


Rotularia. cuneifolia

Fig. 7.

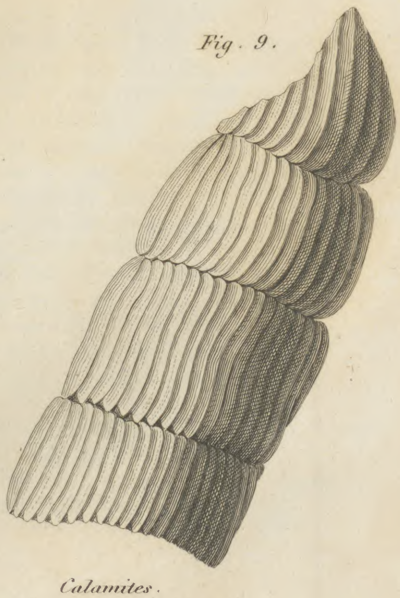
Lepidodendron dichotomum

Fig. 8.



Variolaria ficoides.

Fig. 9.



Calamites. pseudo bambusia

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Organic Remains || Orkney and Shetland.

sometimes met with; also *crocodiles* and *turtles* in a more or less perfectly mineralised state. It frequently contains portions of *fossil wood*, and vast variety of fruit or ligneous seed-vessels. Seven hundred different seed-vessels have been collected, and few of them agree with any known kinds.

3. *Fresh-water Formations.*—These are so named from their containing principally shells resembling those of fresh-waters. The following genera occur here, viz. *Lymneus, Planorbis, Cyclostoma,* and *Helix.* And these are associated with seeds, and with parts of coleopterous insects.

4. *Upper Marine Formation.*—It is remarked of this formation by Parkinson, "A few shells only, which may be placed among those which are supposed to be lost, or among those which are the inhabitants of the distant seas, are here discoverable; the greater number not appearing to differ specifically from the recent shells of neighbouring seas." Besides these shells, there rarely occur *palates of fish*, and fossil *sponges*, and *alcyonia*; and, it is said, *fossil bones* of some unknown animal, and teeth of the *mammoth.*

III. Fossil Organic Remains in Alluvial Rocks.

In the *diluvial* members of this class are found the fossil remains of *elephants, hippopotami, rhinoceri,* &c. already enumerated; while the *post-diluvial* soils contain, principally, the remains of animals and vegetables of the present creation.

IV.—FORMATION OF THE STRATA IN WHICH FOSSIL ORGANIC REMAINS ARE CONTAINED.

Our limits do not permit us to enter into any particular discussion on this branch of our subject, which is, indeed, the less to be regretted from its vague and dubious nature. We shall, therefore, conclude with a very few observations. The primitive rocks, as already mentioned, appear to have been formed before the organic kingdom was called into existence; because they contain neither animal nor vegetable remains. It is in the transition rocks that organic remains first make their appearance; showing, that at their formation, and not earlier, animals and vegetables began to exist; and thus nearly establishing one of the most remarkable and striking facts in the whole range of geological science. For a long period, the organic productions of the earth appear to have been principally marine; as in all the formations extending from the transition class, to the chalk, inclusive, corals, shells, encrinites, echinites, fishes, and marine oviparous quadrupeds, are the predominating fossil animals; and hence the different rocks of those formations must have been formed under the waters of the ocean. But the strata of the coal formation contain, besides marine organic remains, land plants and land shells, and the bituminous marl slate, already mentioned as lying over the coal formation, principally fresh water fishes; facts which lead to the conclusion, that fresh or land water was concerned in their formation. The formations extending from chalk to the alluvial series, from their containing abundant remains of both marine and fresh water animals, show that the waters of the land and the ocean assisted in the formation of these rocks. And lastly, in the diluvial formations containing the remains of so many extinct quadrupeds, &c., we have sufficient evidence of their formation by a great rising of the waters of the ocean, or of a flood; which appears to have been that described in the Bible; while the post-diluvial clays, and sands, and gravels, with their fossil remains of known plants and animals, are formations daily taking place upon the land, and under the sea.

(MMM.)

ORKNEY and SHETLAND, or ZETLAND, two groups of islands in the North Sea, belonging to, and forming together one of the counties of Scotland. The Orkney Isles, which are separated from Caithness by the Pentland Frith, a strait from six to twelve miles broad, are situated between 58° 47′ and 59° 20′ north latitude, and between 2° 24′ and 3° 23′ west longitude from Greenwich. Between these, and what properly form the Shetland group, are the two isles of Fair Isle and Foula; the former lying about 24 miles to the south of the mainland of Shetland, and the latter, supposed to be the Thule of Tacitus, about 20 miles to the west: both of them fall under the general denomination of Shetland. With these exceptions, the Shetland Isles may be placed between 59° 48′ 30″ and 60° 52′ north latitude, and between 52′ and 1° 57′ west longitude. In clear weather they can be distinctly seen from Orkney, from which Fair Isle is only about 36 miles distant. The Orkney Isles have been computed to contain 384,000 acres, which is probably above the truth; and of this, 300,000 are said to be waste, or covered by water. Those of Shetland may be about twice as large as Orkney; of which only about 20,000 acres are supposed to be cultivated. But the very irregular form of the islands, penetrated by arms of the sea in all directions, render those estimates, in the absence of any accurate survey, nothing more than approximations. Orkney is divided into seventeen parishes, composing three presbyteries and one synod; and Shetland into twelve, here called *ministries*, making one presbytery, which is invested with synodical powers. Together they constitute one sheriffdom or stewartry, under the jurisdiction of a sheriff-depute and two substitutes, whose courts are held at Kirkwall in Orkney, and at Lerwick in Shetland. Orkney alone sends one member to Parliament; the landholders of

Situation. Extent. Divisions. Representation.

Orkney and Shetland.

Shetland, owing to their peculiar tenures, or the want of a separate valuation of their estates, having no vote in the election. Kirkwall, the only royal burgh, joins with Dingwall, Tain, Dornoch, and Wick, in electing a member for the Scottish burghs. Of the land-tax payable for the county, two-thirds are levied from Orkney, and one-third from Shetland. The valued rent is L. 57,786 Scots; and the real rent, as returned to the property-tax in 1811, was, for the lands of Orkney, L. 9495, 3s. 6d. Sterling, and for the houses L. 2138, 14s. 6d.; for the lands of Shetland L. 6741, 6s., and for the houses L. 1408; the land rent of both being thus L. 16,236, 9s. 6d. Supposing the extent to be a million of acres, this gives a rent of not quite 4d. the acre; but the landowner derives a profit from the labour of the tenantry, which, though considerable, being indefinite in its amount, and difficult to be ascertained, was not probably included in this rental.

Rental.

Orkney Isles.

The number of the Orkney Isles, besides insulated rocks which bear little or no herbage, here called *skerries*, is 67; of which only 28 or 29 are inhabited; the others, known by the name of *holms*, being employed only as grazing grounds for sheep and cattle. Of the inhabited isles the most southerly is South Ronaldshay, supposed to contain 24 square miles, with a population of upwards of 1600, partly employed in agriculture; much of this island being good arable or grass land; and partly in the manufacture of kelp. To the north-west of this is Hoy, an island of twice the extent, but containing only about a third of the inhabitants, the greater part of it being high land covered with heath. Burray, situated north from South Ronaldshay, from which it is separated by a channel about a mile broad, has an area of only three square miles, but produces grain, green crops, and good pasture, and has a valuable rabbit warren. Farther north is the largest island of the group, called Pomona, or Mainland, extending at least 30 miles from east to west, and containing upwards of 200 square miles. The towns of Kirkwall and Stromness are in this Island; the former having about 2000 inhabitants, and the latter 1400. The harbour of Stromness, to which the entrance is from the south, by a passage only a quarter of a mile in breadth, is particularly safe and commodious, though somewhat difficult of access. Shapinsha and Rousa, each containing from 10 to 12 square miles, partly arable and partly pasture, lie to the north of the Mainland. Beyond these are Stronsa, to the north-east, about 16 square miles; and Eda, north-west from Stronsa, not quite so large; both of them containing a considerable proportion of productive land; the former having two good harbours, and the latter carrying on the manufacture of kelp on such a scale as to afford employment to a great part of its inhabitants. Still farther north lie Sanda on the east, and Westra on the west. Sanda, though only about 19 square miles, has about 1800 inhabitants, being naturally a productive territory, and yielding about a fifth of all the kelp made in Orkney. Both from this and Westra, fishing is carried on to some extent. North Ronaldshay, the most northerly of all the Orkneys, lies about two miles north from Sanda, and upon an area of from four to six square miles, has a population of about 500. If the extent of the Orkneys be only 440 square miles, the estimate given in the *General Report of Scotland*, the population in 1811 would be nearly 53 *per* square mile.

Mainland.

Towns.

Population.

Shetland Isles.

Of the Shetland Isles, the number altogether is about 100; of which upwards of thirty are inhabited, and some of these last are very small. The first to the south is Fair Isle, only about two or three square miles in extent, the inhabitants of which are chiefly employed in the cod fishery. To the north, and a little to the east of this, is the Mainland, or largest of the group, about sixty miles long, and from two to seven miles and upwards broad; having the promontories of Sumburgh-head and Fitful-head on the south, and stretching from thence northward in a form very irregular on all sides. Arms of the sea, here called *voes*, penetrate the land in all directions, so much so, that no part of the island is said to be more than two miles from the sea; and at one place, the isthmus of Mavis Grind, the breadth is less than one hundred yards; and it is surrounded at no great distance by a great many holms and skerries, which give to the landscape, if it may be so called, a singularly wild and romantic appearance, when viewed from the high grounds, which here occupy a much greater proportion of the surface than in the Orkneys. Mainland contains Lerwick, the capital of the Shetlands, having about 1300 inhabitants; and a little to the south-west, Scalloway, the only other town, which now consists of but a few scattered houses, though a place of some antiquity, and formerly distinguished for its castle, and for being the seat of justice. Between this island and Bressay, on the east of Lerwick, is Bressay Sound; so celebrated for being the resort of vessels employed in the fisheries. It is upwards of three miles in length, and from one to two in breadth, and affords safe anchorage to ships of any burden. St Magnus Bay, on the north-west of the Mainland, with an inlet from it called Hammersvoe, also presents a secure retreat for shipping in the most tempestuous weather. On the east of this island, which in extent is greater than all the others put together, the principal islands from south to north are Bressay and Whalsey, and on the west Burra, Papa Stour, and Muckle Roe, and at a distance from these Foula. Bressay and Whalsey contain each about sixteen or eighteen square miles, but the others are much smaller. North from the Mainland is Yell, the next largest of the Shetland isles, about twenty miles long, and eight broad. East from Yell lies Fetlar, consisting of good arable and pasture land. Unst, the most northerly, about two miles from Yell, in extent about forty square miles, also contains much good land, fit for either tillage or grazing. It was here that the French philosopher Biot, in 1817, and in the following year Captain Kater, prosecuted their experiments for the purpose of determining, in this high latitude, the variation in the length of the seconds pendulum. The former has given an animated picture of the country and its inhabitants, in his *Notices sur les Operations*, &c. read to the French Institute in 1818.

Mainland.

Towns.

Population

Assuming the extent of these islands to be 880 square miles, or twice that of the Orkneys, the population in 1811 was at the rate of only twenty-six

Orkney and Shetland.

per square mile. But, if the productive land be little more than 20,000 acres, much of the subsistence of the inhabitants, small as the number is, must be drawn from other sources than their own soil.

Climate.

The climate of these islands is exceedingly moist, and the winters long; yet the cold is not intense, and snow seldom lies more than a few days. The thermometer in the Orkneys commonly ranges between 23° and 68°, and in 1811, a rainy year, the quantity of rain was 29.05 inches. In Shetland, during the summer of 1808, the thermometer was for a few days at 75°, the medium temperature of July and August being about 70°; and it seldom falls 10° below the freezing point. According to Dr Edmondston, the medium temperature of the winter months may be taken at 38°, and of the summer at 65°. On the shortest day of the year the sun is above the horizon five hours and twenty-five minutes. From the middle of May to the end of July it is never dark, the short absence of the sun being supplied by a bright twilight. Yet all these islands are much exposed to high winds, which often destroy the crops, as well as occasion great losses at sea; while, surcharged as the atmosphere commonly is with moisture, the sensation of cold is often greater than what is indicated by the thermometer.

Soil.

Of the arable or productive land, the soil is in general sandy, or a light loam, of no great depth, sometimes upon limestone, but frequently sandstone, and in the latter case it is often much injured by wetness. But by far the greater part of the surface is covered with moss and moor, and exceedingly sterile. Among the minerals are iron, lead, and copper, none of which are wrought at present. In 1817 Dr Hibbert found the chromate of iron in the island of Unst. Marl is very common in Orkney, but much neglected, and also limestone. Beds of limestone occur in almost every parish of Shetland. There is no coal, but peat is every where so abundant, that the inhabitants do not suffer from want of fuel.

Rural Economy.

The rural economy of these islands presents several peculiarities, to which we can only advert very shortly. The proprietors of Orkney derive a greater income from the kelp manufactured on the shores, and those of Shetland from the fisheries on the coast, than from the soil itself; and to obtain a sufficient number of hands for these employments, the land is, in general, divided into very small farms, of which most of the rent is paid in produce and in services;—in Shetland chiefly in butter, and in fish sold to the landlord at a price below that of the market. In Orkney land is let by the *mark*, or merk, an indefinite measure, and not by the acre; and in Shetland, where the same practice prevails, the marks are divided into different classes, such as sixpenny, ninepenny, and twelvepenny marks; terms which, whatever they may have denoted originally, do not now define either their relative extent or value; a sixpenny mark being often as large and productive as a twelvepenny one. Both in Orkney and Shetland nearly all the estates are freehold, though the udal tenure was formerly general in the latter country; but they are burdened with feu-duties and rents, formerly paid to the Crown and Bishop of Orkney, and now to Lord Dundas, the grantee, or lessee of the Crown. Tithes are drawn in kind, and in Shetland are said to be very oppressive. Most of the small tenants hold their possessions only from year to year, having no leases.

Crops.

Oats, bear, or big, and potatoes, are the principal crops; yet the soil and climate are in general well adapted to turnips and clovers, which are now to be found cultivated upon a small scale in many of the islands. All their implements are rude, and, as we should think, ineffective; in many parts the spade is almost the only one in general use. Their native horses, cattle, and sheep, are all diminutive animals, stunted by hunger and cold, particularly those of Shetland; but better breeds are now found in Orkney. The late Mr Malcolm Laing (the well known historian of Scotland), who introduced a flock of Merinos into Orkney in 1808, found them to thrive well, and their wool not to deteriorate, but rather improve. The Shetland horse seldom reaches the height of eleven hands, or the cow the weight of 3 cwt., and the milk which the latter yields, on the common pastures, does not exceed three English quarts *per* day. In Orkney, the number of sheep has been computed at 50,000, and in Shetland at from 70,000 to 80,000. The wool of many of the latter is very fine, and might probably be much improved, as well as the animal itself, by proper treatment. But at present, the sheep depasture promiscuously without being herded; neither shelter nor food is provided against the rigour of a long winter, and disease, when once introduced into the flocks, makes the most cruel ravages. A great many swine are bred in these islands, particularly in the Orkneys. The hair, or rather wool, with which they are covered is made into ropes, "and it is not uncommon for a man who sells his pig to bargain to have his wool returned."—(Shirreff's *Agricultural View.*) Rabbits are found in most of the Orkneys; and geese are reared in great numbers as an article of export.

Live Stock.

Manufactures.

Of the manufactures of this county, by far the most important is kelp, of which the quantity produced in the Orkneys yearly is about 3000 tons, but in Shetland only from 400 to 600 tons; the precipitous shores of the latter islands being less favourable to the growth of the sea-weeds from which it is made than those of Orkney. During the late war, it has been computed that about L.40,000 a year was received by the landholders for the kelp made in Orkney alone; and the people whom it employs, for eight or ten weeks in summer, include a great proportion of the inhabitants. But since peace, the price has fallen so much, that this important branch of industry will perhaps cease to be profitable; and the repeal of the duties on Scotch salt, in the last session of Parliament, which may lead to the production of soda from that article, has filled the proprietors with apprehension that it may soon be annihilated. Before the late war, the linen manufacture was carried on to a considerable extent in Orkney, but has decreased since. Straw-plaiting has been introduced both into Orkney and Shetland, and employs from 1200 to 1400 people, chiefly females. Shetland has been long celebrated for its hosiery. Stockings are knit upon wires in almost every family, and of such different qualities, that while some

Orkney and Shetland.

are valued at L.2 a pair, others are so low as 5d or 6d.

Fisheries of Shetland.

The fisheries are to Shetland what kelp is to Orkney, the great source of employment and revenue to its inhabitants; yet cod and lobsters are caught in great quantities among the Orkney isles, and carried alive to the London market, and the dog and coal-fish, for the use of the inhabitants; the former affording oil, and the latter an agreeable article of food. But the fisheries of Shetland are far more considerable. About 600 boats and 3500 men are employed from the 20th May to the 12th August in fishing for ling, cod, and tusk, called the *white fishing*, at from twenty to forty miles from the coast. The principal stations, or *haafs*, are in the parish of Northmaven, in the north-west quarter of the Mainland. The spacious bay of St Magnus, which is on the south side of this parish, leads to the harbour of Hillswick, where there is good anchorage in from seven to twenty fathoms; and on the beach, which is large and commodious, there are warehouses and salt and fish cellars, with every other necessary accommodation. Another great station is at the *Out Skerries*, east from the Mainland. As the fishermen are also small farmers, it is commonly stipulated that these three kinds of fish shall be delivered to their landlord at so much *per* cwt. of wet fish, the landlord curing them, and taking all further risk upon himself. Two tons and a half of wet fish make only one of dry; of which the quantity annually cured by the landholders was, a few years ago, upwards of 1000 tons; and the price in Shetland was 18s. 6d. the cwt. This was before the discovery of the Cod-bank, which we shall notice immediately. But there is a number of what are called *free* fishers, especially in the two islands of Burra, who being at liberty to sell to whom they please, receive a higher price than the small tenants, and the quantity caught by them is not included in the above. Besides these kinds of fish, halibut, skate, and several others, are got at the same time, all of which belong to the fishermen, without any claim on the part of the landholders; and this is the case also with what is caught on hand-lines during winter and spring. Of these *winter fish*, the annual export is about 65 tons. The herring-fishery was formerly prosecuted by the Dutch to a great extent among these islands. "Some old men," says Gifford, who wrote his *Description of Shetland* in 1733, "say that they have seen in Bressay Sound, at one time, 2200 busses." Since peace, these industrious people have begun to resume their labours, though upon a much smaller scale. But the quantity of herrings caught by the Shetland fishermen on the coast is comparatively trifling; and notwithstanding the encouragement afforded by Parliament, it does not appear that they have embarked to any extent in the deep sea fisheries. One of the most ancient and beneficial branches of the Shetland fisheries is that of the coal-fish, known, according to its age, by the names of *sillock*, *piltock*, and *sethe*. These form a principal article in the subsistence of the lower classes.

Cod-Bank.

In the summer of 1818, an extensive cod-bank was discovered to the west of the Shetland Isles. According to the fishermen, it lies from 25 to 30 miles west from Foula. They refer to the west of the island of Westra, one of the Orkneys, as its origin, and from thence it is continued in a direction nearly north by west, having been variously entered upon in steering from the east, as far as about 20 miles north-west of Shetland, a distance of about 140 miles. The breadth is reported to be from 18 to 45 miles, and the depth of water from 28 to 50 fathoms. The great productiveness of this bank has been fully established. About double the weight of fish was caught on it in 1819 that had been formerly taken by vessels of the same burden in other parts.

Trade.

The nature of the trade of these islands may be anticipated from what we have said of their products. Orkney exports kelp, linen cloth and linen yarn, skins, goose feathers and quills, and a few other articles; and the imports are wine, spirits, groceries, &c. Oatmeal and bear or big appear both among the imports and exports; but it is understood that this range of islands, in ordinary seasons, grows corn enough for the consumption of its inhabitants. The chief exports of Shetland are fish, kelp, oil, butter, and hosiery; and the imports the same with those of Orkney, with the addition of corn, of which it does not raise nearly a sufficiency. The money brought into Shetland by such of the natives as engage themselves as seamen in the whale vessels is computed to amount to no less a sum than L.15,000 yearly.

Poor.

There is no poor rate in this county. It is the practice of the island to board the poor upon the tenantry, in proportion to the extent of their possessions; each pauper having a certain number of families assigned to him, with whom he lives in succession, and who are said to treat him with kindness.

Wages.

The wages of labour cannot be accurately expressed in money, as they are paid partly in produce, and vary much at different seasons, owing to the demand for kelp-making and the fisheries. In Shetland a man-servant will seldom engage for more than nine months in the year. The provisions obtained from their own soil and from the fisheries are sufficiently moderate, but such as must be imported are proportionally high priced. The condition of the labouring classes is understood to have been much improved since the introduction of kelp-making; but it is alleged, that the practice of connecting this kind of industry, and that of the fisherman, with the occupation of land, is incompatible with agricultural improvement. The population of the county, in 1801 and 1811, will be seen in the annexed abstract.

See *The Statistical Account of Scotland.* Barry's *History of Orkney.* Edmondston's *View of Zetland.* Shirreff's *Agricultural View of Orkney and Zetland.* *The General Report of Scotland.* Dr Hibbert's *Description of the Shetland Islands.*

(A.)

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
8,016	8,825	105	20,793	26,031	14,653	2,476	8,478	46,824

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
8,250	9,038	101	20,151	26,002	6,583	1,218	1,237	46,153

ORLEANS, NEW. See UNITED STATES.

ORME (ROBERT), the Historian of British India, born at Anjengo in Travancore, was the son of Dr Alexander Orme: his mother was a Miss Hill, a sister of Mrs Robert Adams.

He was sent to England at the age of two years, and placed under the care of Mrs Adams, who lived in Cavendish Square. His literary education commenced very early, for he went to Harrow at six, having been previously, for a twelvemonth, under the private tuition of a clergyman in the neighbourhood. For seven or eight years he applied to his classical studies as a schoolboy with great diligence; and when he was thirteen, he was placed in the office of the Accountant of the African Company, in order to gain some practical knowledge of the principles of commerce.

In 1742 he went out to Calcutta, and was there engaged in a mercantile house of respectability: he made a voyage to Surat in their concerns, and on his return, in 1743, he received from England the appointment of a writer. Five years afterwards he was promoted to the rank of factor in the Company's service. In 1752, having been desired to give his opinion on the regulation of the Police of Calcutta, he drew up a memorial on the subject, which did great credit to the accuracy and profoundness of his views of the manners, the habits, and the interests of the country.

He returned to England in 1753, upon a visit to his aunt, and he was much consulted, during his stay in London, by Lord Holderness, then Secretary of State, with regard to the policy to be observed towards the French Government respecting the affairs of India. He went out again in 1754, and took his seat as a member of the council at Fort St George. He had here an opportunity of effectually serving the Company by the vigour of his political conduct, and of greatly contributing to the establishment of the decided preponderance of the English interest in India. After the well known affair of the Black Hole of Calcutta, he was particularly active in promoting the appointment of Colonel Clive to the command of the expedition destined to punish the cruelty of the tyrant who was the author of that outrage: although his friendship with Colonel Clive did not continue uninterrupted through life. Mr Orme's exertions on this and other occasions were so highly appreciated by the Directors, that he was nominated as eventual successor to the government of Madras: but he did not stay long enough to profit by the appointment. In the capacity of Accountant-General, he became intimate with Mr Alexander, afterwards Lord Caledon, who was his deputy, and with Mr Dalrymple, the hydrographer, to whom he showed many civilities from a conviction of his merits. Mr Benjamin Robins, the historiographer of Anson's *Voyage*, had also been one of his early friends, that is, during his first residence in India; for this singularly active person died in 1751.

Mr Orme's situation in India was extremely favourable for the acquisition of historical information, which it was the delight of his life to collect; but his health requiring a change of climate, he sailed for Europe on board of the Grantham in 1758. The ship was, however, captured in January 1759, off the Cape of Good Hope, and carried to the Mauritius: after having been detained here for some time, Mr Orme was allowed to proceed to the Cape, and thence to France. He landed at Nantes in the spring of 1760: he paid a visit to Paris, where he amused himself for some months with the literature and the theatres of the day: and his biographer has preserved some interesting remarks that

Orme.

they suggested to him. In October he arrived in London, and engaged a house which had lately been built in Harley Street.

He employed himself for the two succeeding years upon his Military History; sparing no pains nor expence to complete the collection of materials, which he had begun to form in India, and to prepare the work, with all possible care, for the press. The first volume appeared in 1763, and was received with great approbation. The Company not only granted him free access to their Records, but gave him also the appointment of their historiographer, with a salary of L. 400 a year. After this time, he resumed some of his classical studies which he had discontinued so long, as to have forgotten almost all that he had learned: but he soon recovered his knowledge of the ancient languages, and added to them afterwards such of the modern ones as he found likely to be subservient to his pursuits. His hours of leisure were chiefly passed in the enjoyment of literary society: he became a Fellow of the Society of Antiquaries in March 1770; he was intimate about the same time with Lord Sandys, and with Sir James Harris. Sir William Jones, Dr Robertson the historian, Dr Pemberton, Dr Wilson, Athenian Stuart, and Nourse the bookseller, were also among his particular friends; as well as Mr Rouse Boughton, afterwards Sir Charles Rouse Boughton, Bart., to whose urbanity and thorough acquaintance with the Persian language he was indebted for several of his historical documents. He obtained additional information for the completion of his History from the French General de Bussy, who had been much concerned in some of the transactions narrated in his first volume, and who was so much satisfied with his candour and impartiality, that he invited him to his house in the country, and entertained him there, in 1773, with great kindness and hospitality.

After the publication of the second volume of his History, he had ample leisure to amuse himself with literary pursuits of a more general nature: but in 1784, he suffered a severe affliction from the loss of his nephew, Mr Hosea, who was shipwrecked, with his wife and family, upon their return from India, on board of the Grosvenor. In 1792, he retired to Ealing, where he continued to reside till the time of his death, which happened on the 13th January 1801.

Good sense and sound judgment were the principal features of his character: his works are more distinguished by simplicity, clearness, and precision, than by any very powerful eloquence, or a very nice discrimination of character. He was not, however, deficient either in command of language or in poetical feeling. Sir William Jones and Dr Robertson paid him some very high compliments, in their private correspondence, for the elegance and purity of his style: the former of these writers has also characterized him, in his third Discourse, as possessing "an exquisite taste for every fine art." We find also, among a few miscellaneous poems collected by his biographer, a remarkable little Address to the Moon, written at Madras in 1757, which is manifestly the original of a well known Greek epigram and a Latin ode of Sir William Jones: and certainly the compliment of having been "set to music, and much admired," must be considered as far inferior to that of having been repeatedly imitated and translated by a poet of a judgment so correct and a taste so refined, and having been called the production of "a man of great talents, and a particular friend of the translator."

Orme || Oxfordshire.

1. Of his works, the earliest, in its origin, was his *General Idea of the Government and People of Indostan.* It was principally written in 1752, and finished during his return to England in the next year. A part of it was prefixed to his Military History, and it is printed in its entire state among his posthumous works.

2. *History of the Military Transactions of the British Nation in Indostan, from the year* 1745. Vol. I., extending to 1756. 4to. Lond. 1763. Ed. 3, with an excellent index, 1781. A Dissertation on the Mahommedan Conquests and Establishments in Indostan is prefixed to this volume. "No historian," says the author of the *Annual Register for* 1764, "seems to have been more perfectly informed of the subject on which he has undertaken to write: and very few have possessed more fully the talent of impressing it, in the clearest and most vivid manner, on the imagination and understanding of his reader."

The *Second Volume*, published in 1778, carries the history down to the peace of 1763.

3. *Historical Fragments of the Mogul Empire*, from the year 1659. 8vo. Lond. 1782. First published anonymously, but acknowledged and reprinted in 4to in 1805; together with the *Origin of the English Establishment at Broach and Surat*, the *General Idea of the Government and People of Indostan*, and a *Life of the Author*. The Historical Fragments is a work of considerable research, making a sort of episode to the Military History, to which it affords some additions and corrections: it relates principally to the sanguinary Arungzebe and his immediate successors, and to his contemporary, Sevagi the "Morattoe," the professed descendant of Porus. The Essay on the Trade of Surat is a fragment which was left unfinished by the author.

4. Several hundred volumes of Mr Orme's manuscript collections, together with some scarce printed tracts, relating to Oriental history, are carefully preserved in the library of the East India Company.

[*Life* prefixed to the *Historical Fragments*. Jones, *Poeseos Asiaticæ Commentarii.*] (L. I.)

Boundaries, Extent, and Divisions.

OXFORDSHIRE, an inland county of England, chiefly celebrated on account of its capital, which is the principal seat of learning in the British dominions, and from which city it has derived its name. It is bounded on the east by Buckinghamshire; on the south, south-west, and south-east, by Berkshire; on the north-east by Northamptonshire; and on the north-west by the county of Warwick. The river Thames (called sometimes the Isis till it reaches Oxford) is the line of demarkation on the whole of its southern boundary; running between this county and Berkshire with various, and in the latter part of its course most beautiful, sinuosities. The county is of a most irregular figure. Near the centre, in which the city of Oxford stands, it is not more than seven miles in breadth, and at no great distance to

Oxfordshire. the north it is thirty-eight miles. Towards the north it resembles a cone, and to the south it is similarly contracted. Its extreme length is fifty miles. The extent is estimated at 742 square miles, or 474,880 English acres. It contains one city, twelve market towns, and two hundred and seven parishes, and is divided into fourteen hundreds.

Face of the Country. This county is by no means uniformly beautiful. On the north, the absence of hedges, which are supplied by stone walls, gives a dreary appearance to the face of the country. In the centre, it is generally flat and woody, affording few pleasing prospects, though its trees and verdure give it the semblance of wealth. The southern part, from the beauty of its rivers, the gentle swelling of its hills, the verdant meadows between them, and the number of highly embellished residences of rich proprietors, is a district abounding with rural charms. The Chiltern Hills, the highest range in England south of the river Trent, form a part of this portion. They are in many parts adorned with beech woods, and in every interval of these woods cultivated quite to their summits.

Climate and Soil. The climate of the county varies according to the elevation and exposure. In the north, where no hedges impede the winter winds, the cold is somewhat severe, and the Chiltern Hills are frequently enveloped in damp fogs, especially in the more woody parts of them. Mr Arthur Young, in his *Agricultural Survey of Oxfordshire,* has formed a classification of the soils in the different districts of the county, which, like all similar estimates, must be received with hesitation, or at least with many exceptions. The red soil, found chiefly in the north, and by far the most fertile, he estimates at 79,635 acres. The land, provincially called *stone brash,* found in the centre, and whose surface is often covered with stones, amounts to 164,023 acres. The Chiltern lands, whose soil is a loam resting everywhere on a bed of chalk, and covered with flint stones, are 64,778 acres. To these are added 166,400 acres under the description of miscellaneous, which comprehends all sorts of soil, from loose sand to the heaviest clay, and includes the rich meadows on the banks of the rivers.

Agriculture. Though this is wholly an agricultural county, and though much progress in improvement has been made of late years, yet the general practices are by no means equal to the average of those of the rest of England. The most beneficial husbandry is founded upon the valuable water meadows on the banks of the different streams. These are naturally so fertile, that they appear to have prevented that care which would render them still more productive. Little attention is paid to draining, and still less to irrigation, though the good effects of both these practices are obvious, and their accomplishment easy in many circumstances. Some few oxen are fattened, and butter and cheese made in the dairies, but the facility of navigation induces the farmers to make more hay than is consumed by their stock, and to send it to distant and higher markets than their own—nearer to the metropolis. On the arable fields, especially on the stony lands near Burford, the use of oxen for the plough is very common, and the Herefordshire breed is generally preferred for that purpose. The practice of paring and burning the surface prevails in many parts of the county, and in the newly inclosed lands the application of lime as a manure is highly beneficial, whilst on the Chiltern lands it is not found to produce a good effect equal to the expence which attends it.

Rotation of Crops. Where the soils are so various, the rotation of crops must necessarily vary with them. On the red soils, the most usual course is, 1st, turnips; 2d, barley, or spring-wheat; 3d, clover; 4th, wheat; 5th, peas, or beans; and, 6th, oats. On the stone-brash lands, the usual rotation is, 1st, turnips; 2d, barley; 3d, clover, to stand two years; 4th, wheat; and, 5th, oats, peas, or sometimes, but rarely, beans. On the Chiltern lands, the rotations are the same, with only slight variations. On both these last tracts of country, the cultivation of sanfoin is very extensive; on most farms occupying from one-seventh to one-eighth of the whole. This valuable artificial grass produces heavy crops. When it was first introduced, it would remain productive for fifteen or sixteen years; but since it has become more familiarised to the soil, it seldom lasts more than seven years so as to be fit to make hay, but yields food for sheep for one or two years afterwards. The sheep, which were formerly almost all of the Berkshire breed, have of late years been superseded by the race of the South Downs.

Manufactures. Oxfordshire is not a manufacturing district. Witney was celebrated for its blankets, and they still retain their superiority; but the cheapness with which similar goods are made by machinery in the northern counties has reduced the demand; and though machinery has been introduced, the trade is still on the decline. On the eastern side of the county, some females find occupation in making bone lace, but that, too, is on the decline. At Banbury there is a manufactory of plushes, hair-shaggs, and some bindings, and other haberdashery wares; and at Woodstock, the making of gloves gives employment to many of the inhabitants. There are no minerals and no coals found in this county.

Rivers and Canals. The rivers all empty themselves into the Thames. They are formed by the numerous small springs which are everywhere to be seen; and before they join the Thames are called the Windrush, coming from Burford and Witney, the Evenlode, from Wichwood and Charlbury, and the Cherwell, from the vicinity of Banbury. The Thames, composed of the stream of that name and the Isis (on which a strange confusion has arisen), is navigable from near one of its sources, not far from Letchlode, to the sea. The barges navigating it are from seventy-five to one hundred tons burden, but the larger ones ascend no higher than Oxford. From the frequent recurrence of shoals, from the floods in winter, and the scarcity of water in summer, it is a dilatory navigation; so that frequently the passage from America to London occupies less time than from Letchlode to that city. The scarcity of fuel was severely experienced till within these last few years; but the completion of a canal, which connects the city of Oxford with the collieries of Staffordshire, has removed the evil, and proved high-

ly profitable to the proprietors of that important work.

Oxford City. We forbear to say any thing of that which is the glory of this county and of this kingdom—the city of Oxford. It is described in the *Encyclopædia* in a moderate compass, and a farther expansion of that description, by enumerating the works of art and the repositories of everything valuable in literature, would be incompatible with the limits prescribed to this work.

Antiquities. The antiquities of this county have been accurately described, and are deserving of the closest inspection. Among them are the traces of the various roads formed by the Romans, whose principal station was at Dorchester, many funereal mounds, and the Vallum called the Devil's Ditch. The Priory of Godstow, and the ruins of many other religious houses, exhibit the architecture of different and remote ages.

Population. The population of this county had increased, between the years 1801 and 1811, by 9586 individuals. In the last mentioned year, the numbers were, 119,204; of whom the males were 59,140, and the females 60,064. The number of houses were 21,598, inhabited by 24,749 families. Of these persons, 36,409 were employed in agriculture, 17,946 in trade and manufactures, and 64,849 derived their subsistence from neither of these employments. The towns and their population are as follows, viz.—

Oxford city,	12,931
Henley-upon-Thames,	3,111
Banbury,	2,840
Witney,	2,722
Thames,	2,328
Bicester,	2,114
Woodstock,	1,419
Chipping Norton,	1,975
Burford,	1,332
Deddington,	1,296
Watlington,	1,150
Bampton,	1,093

The county is in the diocese of the capital city, which gives the title of Earl to the family of Harley. The members returned to the House of Commons are nine, viz. two from the county, two each from the city and university of Oxford, two from Woodstock, and one from Banbury.

The most distinguished residences are, Blenheim Castle, Duke of Marlborough; Blandford House, Duke of Beaufort; Brightwell, W. Lowndes Stowe, Esq.; Cuddesdon Palace, Bishop of Oxford; Crowsley Park, John Atkins Wright, Esq.; Ditchley Park, Lord Dillon; Grey's Court, Lady Stapleton; Heythorp, Earl of Shrewsbury; Kirtlington Park, Sir H. W. Dashwood; Middleton Stoney, Earl of Jersey; Mongewell, Bishop of Durham; Mapledurham, Michael Blount, Esq.; Nuneham Park, Earl of Harcourt; Rycot Park, Earl of Abingdon; Shiplake, Lord Mark Kerr; Shelswell, ——— Harrison, Esq.; Shirburn Castle, Earl of Macclesfield; Thane Park, Miss Wykham; Wroxton, Earl of Guildford; Wood Eaton, John Weyland, Esq.; Waterstock, W. H. Ashhurst, Esq.; Wormsley, John Fane, Esq.; Wheatfield, Lord Churchill.

See *The Agricultural State of Oxfordshire*, by Arthur Young; Pott's *Oxfordshire*; and Brewer's *Account of Oxfordshire*, in the *Beauties of England and Wales*. (W. W.)

P A L

PALEY (William), D. D., was born at Peterborough in July 1743, where his father was then minor canon of the cathedral church. His father afterwards removed to Giggleswick, being appointed head master of the school at that place. Here his son was trained under his immediate inspection, and discovered a solidity of understanding, and a studiousness of disposition, which gave a fair earnest of his future eminence.

In November 1758, at the age of fifteen, he was admitted a sizar of Christ's College, Cambridge; and in October 1759, he became a resident member. When he left home, his father could not refrain from expressing to his friends the anticipations he entertained of the figure which his son was destined to make. "He'll turn out a great man—very great. He has by far the clearest head I ever met with."

Shortly after his removal to Cambridge, he obtained three scholarships. He was not at this time a close or laborious student; he spent much time in company, and improved himself rather by observation and reflection than by reading. When he appeared in the public school to make his first *act*, the spruceness of his dress presenting a striking contrast to the habitual carelessness of his appearance, attracted very particular notice, and, aided by a singularity in his gestures and manner, occasioned much mirth among the spectators; but the uncommon success with which he acquitted himself had the effect of drawing crowds on all future occasions when he was expected to dispute. His eminent abilities created on one occasion some degree of apprehension, when he proposed to argue against the eternity of future punishments. One of the heads of the college insisted on his relinquishing that question. Dr Watson, then Moderator, and afterwards the celebrated Bishop of Llandaff, protected, on this occasion, Paley's independence. The latter, however, was averse to give offence; and at the suggestion of Dr Watson he retained the subject, but took the opposite side. He

came off with much eclat, his talents having received the best scope for display from the high ability of his opponent, Mr Frere.

After obtaining, with great honour, his bachelor's degree in January 1763, he accepted of the situation of second assistant and Latin teacher in an Academy at Greenwich, chiefly resorted to by young men intended for the army and navy.

In 1765, Mr Paley gained the first senior bachelor's prize by a Latin dissertation on "a comparison between the Stoic and Epicurean Philosophy in their influence on morals;" taking the side of the Epicureans, as a sect friendly to rational pleasures, and not (as their enemies supposed) indulgent to vicious excesses; while he condemned the affected austerity of the followers of Zeno, and showed, from facts, that it was compatible with the most flagitious crimes. It is a remarkable circumstance, as illustrative of the formality which often presides in university matters, that this dissertation narrowly escaped rejection, because the Latin text was accompanied by *English Notes,* for the purpose of aiding philosophical accuracy where the Latin appeared liable to ambiguity.

Being ordained deacon at the proper age, he officiated as curate to Dr Hinchcliffe, Vicar of Greenwich, where he continued to reside, though he gave up his situation in the Academy.

Mr Paley was elected a fellow on the foundation of Christ's College in June 1766; returned to reside in the University; took the degree of Master of Arts; and engaged in the business of private tuition. He took priest's orders in December 1767, and in 1768 he was appointed tutor of Christ's College, along with his friend Mr Law, already a distinguished scholar. The talents and assiduity of these two quickly raised the celebrity of their college to an unprecedented height. Paley's intimacy with Law was productive of much mutual improvement, and introduced the former to the acquaintance of his friend's father, the eminent Dr Edmund Law, who was soon after Bishop of Carlisle, but continued to reside in the university as master of Peterhouse. Mr Paley was at this time held in the highest esteem, and among his particular friends were numbered Dr Plumptre, Professor of Casuistry, Dr Waring, Lucanian Professor of Mathematics, who was in his department eminent beyond his contemporaries, and the accomplished Mr Jebb. He figured as a lecturer on mathematics, morals, and the *Greek Testament,* and afterwards on divinity. His method of lecturing was singularly happy; the result of a diligent study of the art of teaching. He soon discovered that, in moral disquisitions, more pains are required to make young minds perceive the difficulty than to make them understand the solution; and that some curiosity must be raised before an attempt is made to satisfy it. The discourses which he delivered at this time contained the germ of the principal works which he afterwards published on morals and theology.

The controversy on the propriety of requiring a subscription to articles of faith, as practised by the Church of England, was at this time much agitated at the two universities. At Oxford the High Church party was triumphant, and scarcely any individual ventured a whisper of opposition; but at Cambridge talents and ingenuity were exercised on both sides of the question. Paley favoured the claims of the reforming party; but, from motives of prudence, declined signing a petition for relief at that time drawn up; not entertaining such expectations of ultimate success as to be induced to take a public step so obnoxious to those on whom his future prospects depended. He told one of his friends in jest, that "he could not afford to keep a conscience;" a confession which will, no doubt, lay him open to the animadversions of those who reserve their censures for the subdued struggles of a mind of limited moral strength, while they excuse or applaud the oppressive system by which its efforts are overawed. Paley, however, soon after wielded his pen in a decided tone in the cause of freedom. Dr Law, the Bishop of Carlisle, published an able and moderate pamphlet against the imposition of the Church Test. An answer appeared at Oxford from the pen of Dr Randolph. To this Paley published, anonymously, a reply, entitled, *A Defence of the Considerations on the Propriety of the Church Test.*

His well merited reputation induced that great constitutional lawyer, the late Earl of Camden, to offer him the situation of tutor to his son, but his other engagements led him to decline the offer.

In 1775, he was inducted to the rectory of Musgrove in Westmoreland, worth about L. 80 a-year, presented to him by the Bishop of Carlisle. He now married Miss Hewit of Carlisle, and took a small farm to improve his income; a speculation which he soon after gave up as unproductive. Next year, he was inducted to the vicarage of Dalston in Cumberland.

In 1777, he was inducted to the vicarage of Appleby, worth about L. 200 a-year; and while in this situation he published a small volume, entitled, *The Clergyman's Companion in Visiting the Sick;* in which he both evinced his personal attention to the spiritual wants of his own flock, and conferred an obligation on his brethren, which has been acknowledged by the numerous and large editions which it has undergone. In June 1780, he was installed a prebendary of the fourth stall, in the Cathedral of Carlisle, worth about L. 400 a-year; and in August 1782, on the promotion of his friend Mr Law to the see of Clonfert, he was raised to the dignity of archdeacon of the diocese.

A report was long in circulation, that Mr Paley, being appointed to preach before the University of Cambridge when Mr Pitt made his first appearance at St Mary's after his elevation to the premiership, chose the following passage for his text: "There is a lad here who hath five barley loaves and two fishes, but what are they among so many?" That was not the fact; but the joke originated with Paley, who said to a friend that, had he been asked to preach on the occasion, he would have chosen this text.

Now in possession of a competent income, and sufficient leisure, he prepared for the press his great work *On the Principles of Moral and Political Philosophy,* which first appeared in 1785. In conse-

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quence of the well known merit of his lectures on the subject of that work, high expectations were formed of it; and his admirers were not disappointed. Its most obvious feature was that of being all directed to the practice of life in cases which hourly claim the attention of well meaning minds. Most other scientific works on morals were mere speculative treatises, which pleased the reader by unfolding the principles of right and wrong, in cases in which he has been previously satisfied about the practical rule and its application; while they embarrassed conscientious inquirers with hair-breadth distinctions, instead of conveying satisfactory principles. Dr Paley's work happily unites a due regard for practical duty with rational information on those points on which the mind is most anxious to obtain satisfaction. It soon established the reputation of its author. Some of his doctrines met with opposition; but he never was provoked to write any reply; and it is further remarked by his biographer, Mr Meadley, that, in the subsequent editions, he made no alterations materially affecting the sense. Had there been a few such alterations, however, he would have more fully merited the character of a liberal inquirer.—Among his elucidations of the foundations of virtue, he certainly fails in his definition of "the nature of obligation." He acknowledges that the subject had embarrassed his own mind; yet he ultimately reposes in a solution founded on a confusion of terms, which laid him fully open to the animadversions of the Reverend Mr Pearson, who published *An Examination of his Theory*. Dr Paley's doctrine is, that "a man is under moral obligation when he is urged by a violent motive resulting from the command of another." He thus resolves obligation into an effectual inducement. According to this statement, a man is under no moral obligation unless he feels, acknowledges, and acts upon it. Had such a hypothesis occurred in the writings of an author who made the purity of practice to depend on the reception of peculiar theories, it might have created great laxity of principle in the minds of some persons and distress in those of others. But his masterly elucidation of the rule of morals, and the paternal benignity with which his efforts are uniformly accompanied, set his reader at rest from all hurtful anxiety on practical topics.

His exposition of the rule of morals, as founded in utility, is ably managed. He demonstrates the superiority of this rule to every other, and the subordinate rank of all those mental suggestions and impressions, which some moralists have represented as essential parts of the foundation of morality. Many such feelings are valuable provisions of the Author of our nature; but they do not deserve the authority of guides. Their whole claim to our obedience is derived either from their coincidence with some express command of the Deity, or their conduciveness to utility. The difficulties attending inquiries into this conduciveness in particular instances do not generate uncertainties so great as those attached to the other supposed natural tests of moral truth. A man may be mistaken respecting the useful or hurtful *tendency* of a particular line of conduct; but he is equally liable to be led astray by feelings venerated as moral suggestions; and under that influence, he is deprived of an equal possibility of correcting himself by subsequent reflection. When authors declaim on the danger attached to the doctrine of utility, they borrow their arguments from that doctrine itself. They merely set up utility in its extensive application against such utilities as are partial and delusive. Dr Paley, therefore, dwells strongly on the necessity and importance of *general rules;* and by taking them for his guides, obviates all the serious objections brought against his leading theorem, "that the method of coming at the will of God concerning any action, by the light of nature, is to inquire into the tendency of that action to promote or diminish the general happiness."

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On our duties to ourselves his observations are short, at which we cannot be surprised when we find that in his definition of virtue these duties are excluded. In the excellent casuistical *Observations on Self-Defence, Drunkenness, and Suicide,* of which this portion of his work entirely consists, he regards the tendency of personal conduct and habits only as they affect society around us. Had he paid more respect to the maxims of the stoical authors, and studied them in their most favourable meaning, he would have been more disposed to point out the importance of maintaining mental composure as an ultimate object of individual efforts. On our duties towards God he also treats briefly. The simplicity attached to our knowledge of their great Object divests them of variety as a separate subject, without detracting from their sublimity.

In the political part of this work, we find the exertions of a manly understanding employed with some success in exposing the dark bigotry and the gratuitous king-worship by which political knowledge had in past ages been disgraced. His efforts, however, are exempt from those headstrong tendencies which minds liberated from unfair control sometimes betray, to run into schemes incapable of being applied without compromising the happiness of society. That happiness he keeps steadily in view, as the only legitimate object of all government, as well as the only legitimate object of opposition to existing practices and institutions. Some of his admirers consider him as going too great lengths in vindicating the exaction of a subscription to the Thirty-nine Articles. His chapter on subscription has been assailed with equal asperity by the strenuous adherents of the established church, and by the scrupulous advocates for Protestant freedom. His biographer, Mr Meadley, calls it "the last effort of an ingenious mind to soften, by interpretation, the rigour of a practice of which he could not seriously approve, and so to enlarge the pale of conformity to liberal and conscientious men."

The answer which he gives to the arguments for passive obedience as founded in Scripture is particularly worthy of attention. Through the whole he displays a candour of the most conciliating kind. None of his strictures on existing systems had the slightest tendency to give offence to any, except to persons actuated by downright prejudice, or the most corrupt motives.

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On the death of Dr Law, Bishop of Carlisle, which happened in 1787, Mr Paley published a short *Memoir* of the life of that venerable prelate. Soon after he wrote two tracts in favour of "the abolition of the slave trade;" a subject on which he had expressed his sentiments with decision in his *Principles of Moral and Political Philosophy,* before it began to excite general interest.

In 1790 he published his *Horæ Paulinæ,* or *the Truth of the Scripture History of St Paul evinced, by a comparison of the Epistles which bear his name, with the Acts of the Apostles, and with one another.* The object was to show, by a copious selection of references and reciprocal allusions, the strong evidence of their genuineness derived from their undesigned coincidence. This able treatise possesses more novelty of interest, and greater originality of idea, than any of his other works.

During the political ferment which led to the French Revolution, Dr Paley published a short tract, entitled, *Reasons for Contentment, addressed to the Labouring Classes;* and he republished, in a separate form, his chapter *On the British Constitution,* from his *Principles of Moral and Political Philosophy.* He was censured by the violent partisans on both sides, as he went the full lengths of neither; but his style of reasoning had the best tendency to guide and satisfy those minds which were not obstinately and unreasonably prepossessed.

In May 1791, Mrs Paley died, leaving a family of four sons and four daughters.

Early in 1794 he published his *View of the Evidences of Christianity.* This work, with regard to manner and effect, follows a happy medium between that learned prolixity which deters the reader, or tires out his patience, and that abrupt brevity which is apt, with some minds, to beget an unfortunate impression of some imperfection in the argument. He contends for the substantial truth of the history connected with the Christian revelation; and, not undervaluing, as some have injudiciously done, the internal evidences, he exhibits, in primitive simplicity, and without the least oratorical exaggeration, the superlative value of those doctrines in which all Christians are agreed, and gives an animated view of the morality of the gospel. The work, considered as addressed to doubting minds, was well fitted to interest the attention of all who are duly impressed with the importance of the question at issue.

Hitherto his preferment in the church had been slender, considering his singular merit and the opulence of the ecclesiastical establishment. The boldness of his reasonings on political subjects had given deep dissatisfaction. To the favourers of power, it was not welcome doctrine, that "governments may be too secure;" that "the obligations of subjects and sovereigns are reciprocal;" and "that the divine right of Kings rests on the same foundation with the divine right of Constables." But when he stood forth as the successful defender of the Christian revelation, at a time when the interests of the church were supposed to be in danger, his services met with more marked attention. Dr Porteus, Bishop of London, conferred on him the desirable situation of prebend of St Pancras in the cathedral of St Paul's, to which he was instituted in August 1794. He was in a few months after promoted to the sub-deanery of Lincoln by Dr Prettyman, Bishop of that diocese, and took his degree of D. D. at Cambridge.

Before leaving this place, he had the agreeable surprise of a letter from Dr Barrington, Bishop of Durham, offering him the valuable rectory of Bishop-Wearmouth, worth about L. 1200 a-year, into which he was soon inducted. A few months after he married Miss Dobinson of Carlisle, and, from this period to his death, divided his time between Bishop-Wearmouth and Lincoln; being obliged to reside three months in the year at the latter place. Now that he enjoyed a handsome independence, we find his company courted by many distinguished characters, and his life spent in a series of the most useful labours, while all his secular transactions were so well conducted, as to shed a lustre on his character, and to exhibit a most instructive example to all around him. Both his parents lived to witness his high reputation and success in life. His mother died in 1796, and his father in 1799.

In 1800, Dr Paley was attacked by a disease in the kidneys, accompanied with a species of melæna, which obliged him to suspend the discharge of his professional duties. He had a second attack in the following spring, and a third about the end of 1802.

During the progress of this fatal disease, he was engaged in preparing for the press his last important work *On Natural Theology.* His literary labours were frequently interrupted by severe paroxysms of pain, but on the first respite, he always resumed them with cheerfulness. Under these circumstances, he wrote his excellent remarks on the alleviations of pain, in his chapter *On the Goodness of the Deity.*—This work had been undertaken at the suggestion of the Bishop of Durham, that he might, by theological exertions in his closet, make up for the unavoidable suspension of his public ecclesiastical labours. In none of his writings does his candour appear to such incontestible advantage as in this. We never find him brow-beating the adversary, or attempting to push his conclusions a single step farther than his premises evidently warrant. We do not find him with many others advancing the metaphysical position, "that every thing which exists must have a cause," so glaringly open to the query, "why should the world have a cause more than its Creator?" Mere existence cannot authorize the inference of owing that existence to a higher source. He rests his argument on far better ground,—the *character* of the fabric of nature, or rather of various objects in it which offer themselves to our observation. Nor does he, with some, assume the doctrine, that matter is essentially inert, and that, therefore, its motions must be induced by an extraneous and spiritual cause. He more wisely turns his attention to the proofs of *design* which so many objects in the world exhibit. These are so selected and arranged, as to appear in the most interesting and satisfactory point of view. Where the phenomena are apparently inconsistent, we find no straining to reconcile them; no reluctance to take a full view of unfavourable appearances; no inclination to draw the same inferences from opposite facts. His argument is not

suspended on a chain of metaphysical reasoning, which would have subjected it to the risk of destruction as soon as one of the links gives way. He directs the attention of his reader to numerous columnar supports of the existence of a God, each of which is adequate to the whole office. Each instance adduced is decisive of the point at issue; and though his instances are numerous as well as beautiful, they are evidently only partial exemplifications of a species of evidence which is boundless in extent.

In the present state of the learned world, this is the most important of Dr Paley's works; as possessing the best tendency to reclaim persons wandering in the mazes of scepticism to that state of thought which is most favourable to the true improvement of the human character; and to the establishment of that state of mental peace after which a sense of our weakness naturally leads us to aspire.

After its publication, Dr Paley continued to take a lively interest in the literary and scientific discussions of the day; especially such as bore directly on the great interests of society; but in May 1805, he was subjected to a violent attack of his complaint, in which all remedies proved ineffectual; and, with great tranquillity, he breathed his last at Bishop-Wearmouth, leaving a family of four sons and four daughters in possession of a competent fortune, saved by a systematic, though by no means a niggardly economy.

He wrote several sermons and other minor productions, less known than those above enumerated. They are all collected in a uniform edition of his works, and will be found, on examination, worthy of his fame, and successfully directed to the same valuable ends with his more celebrated productions.

(R. R.)

PALLAS (Simon Peter), a distinguished naturalist and geographer, born 22d September 1741, was the son of Simon Pallas, a surgeon in the Prussian army, and Professor of Surgery at Berlin.

He received the early part of his education in his father's house, and his instructors bore ample testimony to the rapidity of his progress. At the age of fifteen he began to attend medical lectures, and he applied so closely to practical anatomy, that in 1758 he was found qualified to deliver a course of public lectures on that science. In the same year he went to Halle, and became the pupil of Segner, continuing also his studies of zoology, and in particular of entomology, with great assiduity. In 1759 he removed to Gottingen, where he made a variety of experiments on poisons, and on other active medical substances, and commenced his observations on parasitical animals. In July 1760 he went on to Leyden, in order to attend the lectures of Albinus, Gaubius, and Musschenbroek, and at the end of the same year he took his degree of Doctor of Physic. The following summer he proceeded to England, principally with the view of completing his medical education, although he devoted the greater part of his time to the active pursuit of natural history, being assisted and encouraged by the friendship of Peter Collinson, and of some other British naturalists, which procured for him a few years afterwards the distinction of having his name inserted in the list of the Foreign Members of the Royal Society, at the early age of twenty three. He visited several parts of the coast of England, in order to examine its marine productions, and his love of natural history enabled him to profit in a similar manner by an accident which detained him some time at Harwich, on his return to the Continent, in the spring of 1762.

Having paid a visit to his native city, he went again to the Hague, and established himself as a resident there under the patronage of Gaubius. On occasion of the publication of a miscellaneous work on zoology, which he dedicated to the Prince of Orange, he proposed a plan for an expedition to the Cape of Good Hope, and to the Dutch East Indies, which he offered to conduct in person; but although the project was encouraged by Gaubius, and approved by the Prince, his father's interference prevented its execution, and obliged him to return to Berlin. His filial affection, however, was not strong enough to induce him to refuse the invitation of the Empress Catharine to Petersburg, where he accepted, in the year 1767, the appointment of Professor of Natural History in the Imperial Academy of Sciences.

The first few months of his residence at St Petersburg were employed in preparing his *Zoological Gleanings* for publication, and in making catalogues of some collections of natural history. It was now that the more active career of his public life was about to commence, and in 1768 he undertook, in common with Falk, Lepechin, and Guldenstädt, the conduct of an expedition sent out by the Empress for the joint purposes of observing the transit of Venus, and of investigating the natural history and geography of Siberia, and the neighbouring countries. The object of their researches for the first summer was the province of Kasan, and the winter was passed at Simbirsk; the next year they examined the shores of the Caspian, and the borders of Calmuc Tartary; they returned through Orenburg, and passed the winter at Ufa. In 1770 Pallas crossed the Uralian mountains to Catharinenburg, and, after examining the mines in that neighbourhood, proceeded to Tobolsk. The next year he went to the Altaic mountains, traced the course of the Irtish to Kolyvan, went on to Tomsk, and observed the natural freezing of quicksilver at Krasnoyarsk, on the Yenisei, in latitude $56\frac{1}{2}°$ north. He proceeded in March 1772 by Irkutsk across the Lake Baikal, as far as Kiatka, and returned to Krasnoyarsk. In 1773 he visited Tara, Astracan, and Tzaritzin, on the Volga, and returned to St Petersburg in 1774, after an absence of six years. About ten years later he was made a member of the Board of Mines, with an additional salary of L. 200 a year, and he was complimented with the title of a Knight of St Vlodimir. The Empress purchased his collection of natural history for a price one third greater than his demand, and allowed him, at the same time, to keep it in his possession for the remainder of his life.

In 1794 he took a journey into the Crimea, and was captivated with the beauty of the country and its productions; the climate also appearing to be such as his health was supposed to require, he obtained from his munificent patroness not only permission to establish himself there, but a grant of a large and fertile estate, and a sum of 10,000 rubles

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to assist him in his outfit. He was thus enabled to build a little palace, rather than a country house, in which a traveller from the North of Europe was sure to receive the most obliging hospitality, as Dr Clarke has made well known to the English reader. It appears, however, that the air was not altogether exempt from the miasmata, which are the causes of paludal fevers; and some other circumstances, besides the distance from all civilized society, seem to have made the old age of Pallas more cheerless than he had anticipated to find it, in the independence and tranquillity of his patriarchal establishment at Akmetshet. About ten years after the period of Dr Clarke's travels, he undertook a journey to Berlin to pay a visit to his brother, and died there in September 1811.

Linné the younger has given him a genus, *Pallasia*, in his *Supplementum Plantarum*; a compliment to which his unremitting labours, in every department of natural history, had amply entitled him. His collection of dried plants was purchased by Dr Clarke's fellow traveller, Mr Cripps, and is now in the possession of Mr Aylmer Bourke Lambert.

The general character of Professor Pallas's acquirements appears to have been that of extent and variety, together with fidelity. He was not the author of any new theories, or improved systems; and it has sometimes been observed, as by Murray in his *System of Vegetables*, that his descriptions were somewhat defective from the omission of correct specific distinctions; but this omission is of such a nature as to affect a compiler, or a book-maker, more than an actual student of natural history, who is studying for his own improvement only, and who is capable of entering into a detailed examination of the objects concerned. To such a detail the principal part of Professor Pallas's works have related; and it is impossible to enumerate the whole of his memoirs without making a pretty extensive catalogue of the productions of the various kingdoms of nature.

1. His *Dissertatio Inauguralis de Infestis Viventibus intra Viventia*, 4. Leyd. 1760; containing a systematic account of intestinal worms, is said to have been previously published in another form at Gottingen, a short time before he went to Leyden. 2. We find in the *Philosophical Transactions* for 1763, p. 62, a short note *On the Cold observed at Berlin* the preceding winter. 3. In the volume for 1766, p. 186, a description of the jaculator fish, or *Sciaena jaculatrix* of the Indian Ocean, which catches insects by darting drops of water at them; this description is repeated in the *Spicilegia Zoologica*, Fasc. 8. 4. *Elenchus Zoophytorum*, 8. Hague, 1766; containing near three hundred species; *Dutch by Boddaert*, with figures, 8. Utrecht, 1768. 5. *Miscellanea Zoologica*, 4. Hague, 1766; consisting of descriptions and dissections. 6. *Spicilegia Zoologica*, 4. Berl. 1767-1780. Of this valuable collection of memoirs, intended for the description and illustration of new or little known species of animals, there appeared in the whole 14 fasciculi; some of them were published by Professor Martin, during the author's absence in Siberia. We find, among other articles, an interesting account of the *musk deer*, of various species of the *antelope*, and on the different varieties of *sheep*, both wild and tame; the latter has been published in English; *On Russian and Tartar Sheep*, 8. Edinb. 1794. 7. In the *N. Act. Acad. Nat. Cur.* III. p. 430, *Phalaenarum biga*; an account of two species of moth, of which the females are without wings, and spontaneously fertile. 8. A variety of miscellaneous papers, by Pallas, appeared in the *Stralsund Magazine* which began to be published at Berlin in 1767; they chiefly relate to the *Winter Residence of Swallows*, Vol. I. p. 20; to *Hydatids* found in the abdomen of ruminant animals, and supposed to be a species of tænia, p. 64; to the *Birds of Passage of Siberia*, p. 145; from Heller's *Notes*; to Firmin's supposed discovery of the *Origin of the Belemnite*, p. 192; to some *Peculiarities of Insects*, p. 225; to a *Poison* supposed to be prepared in Siberia from the *Sitta* or nuthatch, p. 311; to the *Elk or Moose Deer*, p. 382, from Heller's papers; and to the use of the *Sphondylium* in Kamtshatka, p. 411. 9. *Collections relating to the Mongol Tribes*, published in 1776, and showing that they are distinct from the Tartars.

10. Professor Pallas's contributions to the *Memoirs* of the Imperial Academy of St Petersburg are also very numerous, and on miscellaneous subjects. In the *Novi Commentarii* we find an account of the *Tubularia Fungosa*, Vol. XII., observed near Wolodimer; *Lepus pusillus*, and *Fossil Bones of Siberia*, Vol. XIII.; *Quadrupeds and Birds observed in* 1769, Vol. XIV. i.; *Remains of Exotic Animals in Northern Asia*, Vol. XVIII., especially the skulls of the rhinoceros and the buffalo; *Tetrao arenaria*, *Equus hemionus*, and *Lacerta apoda*, Vol. XIX.; the last also in *Geneesk. Jaerboek*. II. In the *Acta* for 1777, ii., *An Account of the Teeth of an Unknown Animal*, like those which have been found in Canada; *Observations*, from Camper's Letters, *on a Myrmecophaga*, and a *Didelphis*; and *Equus asinus*, in the wild state. In the volume for 1779, ii., a *Description of Plants peculiar to Siberia*; *Capra Caucasica*, also in Lichtenberg's *Magazin*, II. For 1780, Part i., *Galeopithecus vitans*; Part ii. *On the Variations of Animals*; and *Didelphis brachyura*. For 1781, Part i., *Felis manul*, a new Asiatic species of Felis; ii., *On some Species of Sorex*. In the volume for 1783, *New Species of Fishes*; and 1784, *On some new Marine Productions*.

11. The *Observations sur la Formation des Montagnes, et les Changemens arrivés au Globe, particulièrement à l'égard de l'Empire Russe*, published separately, 4. Petersb. 1777, were also inserted in the *Acta* of the Academy for 1777, having been read at a public sitting before the King of Sweden. A translation of this discourse is inserted in Tooke's *Russian Empire*, and some remarks on it are found in the *Journal de Physique*, Vol. XIII.

12. The most considerable of the separate publications of Pallas was the account of his travels, entitled *Reise durch verschiedene provinzen des Russischen Reichs*, 3 vols. 4. Petersburg, 1771-3-6; *French*, 8vo, 8. Par. 1803; *English*, 2 v. 4. London, 1812; a work of the highest authority in geography and natural history. 13. It was in the course of these travels that Pallas observed in Siberia an insulated mass of *native iron*, which he described in a paper, addressed to the Royal Society of London, and printed in the *Philosophical Transactions* for 1776, p. 523; a substance which has become the

Pallas.

Pallas || Panorama.

subject of many discussions, from its resemblance to some of the specimens of well ascertained aerolites: the author mentions also the remains of an unmineralised rhinoceros, which had been found in the same country.

14. In the *Beschäftigungen Naturforschenden Freunden*, published at Berlin about 1777, we find a letter on the *Acipenser ruthenus*, or *Sturgeon*, Vol. II. p. 532, and *An Account of a Monstrous Horse*, Vol. III. p. 226. 15. Some *Mineralogical Observations*, addressed to Born, are published in the *Böhmische Abhandlungen*, Vol. III. p. 191. 16. In the Swedish *Handlingar* for 1778, we have the *Alauda Mongolica*, and the *Sturnus Daauricus;* the *Anas glocitans*, in 1779.

17. *Novæ species Glirium*, 4. Erlang. 1778. 18. *Icones Insectorum, præsertim Rossiæ Sibiriæque*, 4. Erlang. 1781. 19. *Enumeratio Plantarum Procopii a Demidoff*, 8. Petersb. 1781.

20. Another channel, in which a number of Pallas's most valuable essays appeared, is the work entitled *Neue Nordische Beyträge*, which he published at St Petersburg and Leipzig, in 1781 and the following years. The most remarkable of the subjects of these are, *A great Exotic Animal found in Kasan in the year* 1776 ; *On the Migration of the Water Rat on the Volga*, and *Observations on Tæniæ*, Vol. I.; *Further Remarks on Tæniæ ; On American Monkeys, bred at St Petersburg ; On the Ardea helias ; On the Culex lanio, sometimes fatal to Cattle ; On the Phalangium, or Scorpion Spider ;* and *On Copper Island, in the Sea of Kamtshatka*, Vol. II.; *On Two Birds ;* and, *On the Labrador Stone*, Vol. III.; *On a Cross of the Black Wolf with the Dog ; On a Mine ; On the Oriental Turquois ;* and, *Mineralogical Novelties from Siberia*, Vol. V.

21. In the *Physische Arbeiten* of Vienna, we have a geological *Essay on the Orography of Siberia*, Vol. I. i.

22. *Flora Rossica*, f. Vol. I. Petersb. 1784; II. 1788, published at the expense of the Empress.

23. *Tableau Physique et Topographique de la Tauride*, 4. Petersb. 1795; German in *N. N. Beyträge*, VII. A work derived chiefly from the observations made by the author in his travels of 1792.

24. A *Monography of the Astragali* is mentioned by some of his biographers.

25. He edited also Guldenstädt's *Reisen durch Russland und in den Caucasischen gebirgen*, 2. v. 4. Petersb. 1787–1791. 26. He also compiled and arranged the two first and most valuable of the four volumes of the *Vocabularia Comparativa*, 4. Petersb. 1787; in which he attempted to make some improvements in the Russian orthography. See LANGUAGES.

[Coxe's *Travels ;* Clarke's *Travels ;* Tooke's *Russian Empire ;* Halleri *Bibliotheca Anatomica ;* Aikin's *General Biography*, Vol. X. 4. Lond. 1815. Chalmers's *Biographical Dictionary*, Vol. XXIII. 8. Lond. 1815. Dryander, *Bibliotheca Banksiana*.]

(I. S.)

PANORAMA.—A Panorama is a picture drawn on the interior surface of a large cylinder, representing the objects that can be seen from one station, when the observer directs his eye successively to every point of the horizon. A picture drawn on a vertical plane in the usual way includes only that portion of the sphere of vision that can be seen from one point opposite to the picture, without turning the eye; this portion may comprehend about 60 degrees of the horizon. There are compositions, comprehending the visible hemisphere, and sometimes nearly the whole sphere of vision ; in these compositions, one connected scene is represented on the interior surfaces of a polyhedron, or of a curved solid, the point of sight being in the centre of the polyhedron, and the eye being turned round on its centre, to each of the surfaces, in order to view the whole scene. Of this kind are the gnomonic projection of the sphere on the interior surfaces of a cube, and several pictures, in which one connected subject is represented on the ceiling and the sides of a room ; such as the picture of Jupiter fulminating the Giants, by Julio Romano, on the walls and hemispherical ceiling of a round room in the Palazzo del T, at Mantua ; or the architectural representations and ornaments in Raphael's loggia in the Vatican. Objects are also sometimes projected on the interior surface of a sphere, the eye being placed in the centre ; as in a large hollow sphere with the constellations, which was constructed at Pembroke College, Cambridge. These projections, where the eye, remaining in the point of sight, is turned round on its centre to view the different parts of the picture, are formed on the same principle as the panorama.

Panorama. Panorama on a Polyhedron.

Cylindrical Panorama.

The cylindrical surface is the most convenient for panoramas of landscapes ; and the specific employment of a large cylindrical surface for representing the landscape of the whole circle of the horizon, is the invention of Mr Barker, who brought the panorama into use, and still continues to exercise his art. The cylinder on which the panorama is painted is commonly about 60 feet in diameter. The projection or perspective of a panorama is formed by imaginary lines drawn from different points of the surrounding objects, to the point of sight in the axis of the cylinder. The intersections of these lines with the cylindrical surface form the corresponding points in the panoramic picture. Where the picture is projected on a plane, as in common perspective, and in the gnomonic projection of the sphere, the cones formed by imaginary lines or rays passing from the point of sight to the different objects, are cut by the plane of the picture ; consequently, the sections being formed by a plane, are curves, of which the curvature is always simple. In the perspective of the panorama, where the picture consists of the intersection of the cones of rays by a cylinder, these intersections are, in many of the cases, doubly curved curves. When the picture of a straight line, which is neither parallel to the horizon nor to the axis of the cylinder, is drawn on the cylinder of the panorama, the picture of the line is part of an ellipse, because the oblique section of a right cylinder, by a plane passing through the axis, is an ellipse ; when the cylinder is developed and unrolled on a plane surface, this ellipse becomes the curve called the sinical curve. The projection of lines on the interior surface of a cylinder is also employed in drawing Mercator's charts. But in the projection of the panorama, the field extends only a few degrees above and below the horizon, whereas, in the projections

of the sphere, the field extends many degrees on each side of the plane, which is at right angles to the axis of the cylinder. In drawing a panorama, as well as in drawing a picture on a plane, the horizontal angles between different objects may be observed by a plane table or theodolite; and the elevation of the objects above the horizon, or their depression, may also be observed by the theodolite: the horizontal angles are to be laid down by setting off on the graduated horizon of the cylindrical picture the number of degrees observed; the vertical angles on the cylinder are the tangents of the angles observed, the radius being the semidiameter of the cylinder. (Y.)

PANTOGRAPH, an instrument contrived for the purpose of copying drawings, so that the copy may either be of the same size, of a greater, or of a less size than the original. It consists of four moveable rulers fixed together by four pivots, and forming a parallelogram. At the extremity of one of these rulers prolonged is a point, which is drawn over the lines of the original drawing, whilst a pencil, fixed at the end of another branch of the instrument, traces on paper the lines of the copy. The pencil is placed in a hollow cylinder, and a weight is added on the top of the pencil; by this means, the point of the pencil is made to press on the paper with the force requisite for drawing the lines. The improvements in the construction of different parts of the pantograph described in the *Memoires de l'Acdes Sciences*, 1743, have been generally adopted.

Reducing by a Reticula.

The pantograph, however, is not found convenient in practice; and, for the purpose of copying maps, plans, and other designs, artists most commonly employ the method of dividing the original design into a number of squares, and the paper on which the copy is to be made into the same number of squares. When this is done, they copy the lines contained within each square of the original, so as to form a similar figure within the corresponding square of the reticula which covers the copy.

Reducing by a Triangle.

When the drawing consists of straight lines, a reduced copy is accurately made by means of an isosceles triangle, in which the base is to the side as any line of the copy is to the corresponding line in the original. By setting off with the compasses any line of the original drawing on the sides of the triangle, the base which completes the triangle is the length of the corresponding line to be laid down on the copy. The same operation is performed by the sector.

Tracing.

If a drawing is to be copied, of the same size as the original, without diminution or enlargement, engravers usually trace the copy on oiled paper laid over the original, or on the transparent *papier de guimauve* (marsh-mallow paper), made in France.

Conical Pantograph.

A pantograph has been made, consisting of a rod, placed vertically, and turning round a fixed point in its length, situated between its upper and lower extremity: the upper end of the rod being a point which is conducted by the hand over the lines of the original drawing; the lower end of the rod being the pencil which traces the copy on paper. An instrument upon this principle is sometimes used for drawing the profile of the face, in order to form small portraits or silhouettes.

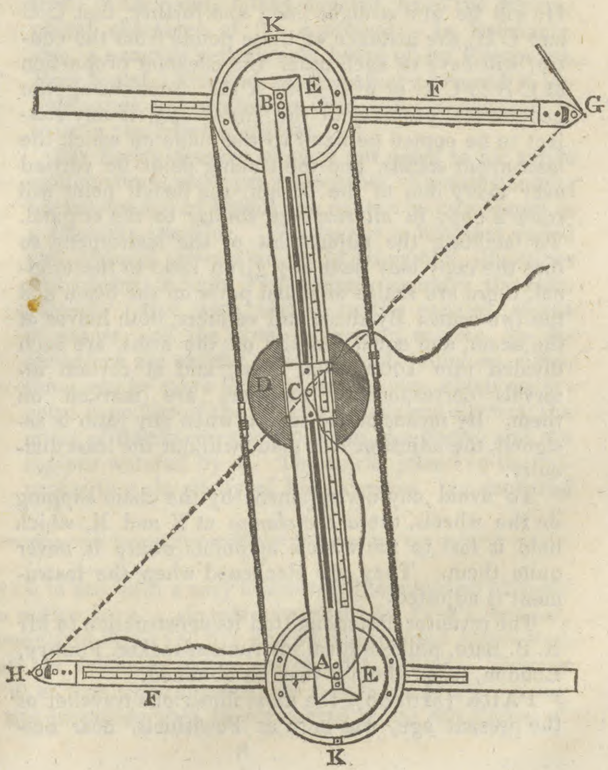
The instrument called Micrograph and Prosopograph in Puissant's *Geodesie*, does not differ in principle from the common pantograph. (Y.)

A very ingenious instrument for copying drawings, either upon a reduced or enlarged scale, has been lately invented by Mr Wallace, Professor of Mathematics in the University of Edinburgh. Of this instrument, which may be fitly introduced under the present head, though differing in *name*, we have been favoured with the following description.

It is a fact well known, that artists of various descriptions, who have frequent occasion to imitate original designs, have long felt the want of a convenient mathematical instrument, by which a copy may be made with neatness and expedition, that shall have any given proportion to the original. The *Pantograph* is the only instrument that has been hitherto employed; but although correct and plausible in theory, in practice it is found to be so very imperfect, that the artist hardly ever thinks of making use of it.

A consideration of the essential service that would be rendered to the graphic art, by a copying instrument, which should be at once simple in its theory and easy in its application, induced Mr Wallace to turn his attention to the subject; and, in the summer of 1821, he produced the model of a copying instrument, which he has denominated an EIDOGRAPH (from ειδος and γράφω). The instrument, and its application to the copying of a great variety of subjects, has been shown to engineers, engravers, and other competent judges in London and in Edinburgh, and their opinion of its utility has been such as to leave no doubt of its completely fulfilling the views of the inventor.

The instrument is represented in this figure:



The *beam*, A B, which is made of mahogany, slides backward and forward in a *socket*, C: the socket turns on a vertical axis, supported by the *fulcrum* D, which stands on a table. There is a slit in the beam, through which the axis of the socket passes, so that, when the beam slides in the socket, a portion of it passes on each side of the axis. There are two equal wheels, E, E, below the beam, which turn on axes that pass through pipes fixed at A, B, near its extremities; and a steel chain passes over the wheels as a band, by which a motion of rotation may be communicated from the one to the other. There are two *arms*, F, F, which slide in sockets along the lower face of the wheels, just under their centres: at the extremity, G, of one arm, there is a metal *tracer*, with a handle attached to it, by which its point may be carried over the lines in any design; and at H, the extremity of the other arm, there is a black-lead *pencil* fixed in a metal tube, which is ground to fit so exactly into a pipe, as just to slide up or down. In using the instrument, the pencil, in its tube, is raised by a thread which passes over a pulley, and it descends again by a weight with which it is loaded.

From the perfect equality of the wheels, it is easy to see that, if the arms attached to them be placed parallel in any one position, they will retain their parallelism, although one of the wheels, and consequently both, be turned on their centres. Supposing, now, that BC and AC, the parts into which the axis is divided at the centre, have any proportion whatever to each other, if the distances of the tracing point G, and pencil point H, from the centres of their wheels have the very same proportion, then it follows, from the elements of geometry, that the tracing point G, the centre C, and the pencil point H, will be in a straight line; and further, that C G and C H, the distance of these points from the centre, will have to each other the constant proportion of C B to C A, or of E G to A H. Such being the geometrical property of the *Eidograph*, if any subject to be copied be fixed to the table on which the instrument stands, and the tracing point be carried over every line of the design, the pencil point will trace a copy in all respects similar to the original. To facilitate the adjustment of the instrument, so that the copy may have any given ratio to the original, there are scales of equal parts on the beam and the two arms: By these and verniers, both halves of the beam, and equal lengths on the arms, are each divided into 1000 equal parts, and at certain intervals corresponding numbers are marked on them. By means of the scales, when any ratio is assigned, the adjustment is made without the least difficulty.

To avoid any derangement by the chain slipping on the wheels, there are *clamps* at K and K, which hold it fast to the wheels at points where it never quits them. They are slackened when the instrument is adjusted.

The inventor has committed its construction to Mr R. B. Bate, philosophical instrument-maker, Poultry, London, from whom it may be obtained.

PARK (Mungo), the most illustrious traveller of the present age, was born at Fowlshiels, near Selkirk, upon the 10th of September 1771. His father occupied the farm of Fowlshiels, under the Duke of Buccleugh. He appears to have bestowed uncommon attention on the education of his children. He even employed a tutor to reside in his house, an expence which then especially was supposed to exceed the resources of an ordinary farmer. Young Park made a good figure at school. His general demeanour was reserved and thoughtful; yet occasional sparks of ambition broke forth, indicative of that adventurous spirit which lay concealed under a somewhat cold exterior. This thoughtful disposition led his friends to consider the church as the profession best suited to his character; but as he himself preferred the medical line, his wishes were acquiesced in; and he spent three years at the University of Edinburgh, in the studies necessary to that profession.

At Edinburgh, Park studied with ardour and success; and he in particular imbibed a fondness for botany, which served strongly to give the colour to his future life. It strengthened his natural connection with his brother-in-law, Mr James Dickson, who, notwithstanding many disadvantages, attained such skill in that science, that, on going as a gardener to Hammersmith, he obtained a large share of the patronage and favour of Sir Joseph Banks. This connection induced Mr Park to repair to London. He was introduced to Sir Joseph, who was so much pleased with him, that he obtained for him the appointment of assistant-surgeon to the Worcester East Indiaman. In this capacity Mr Park made a voyage to Bencoolen, where he made some collections and observations in botany and natural history, which were submitted to the Linnean Society, and an account of them printed in the third volume of their *Transactions*.

The African Association were now anxiously looking for a successor to Major Houghton, their unfortunate missionary, who had perished in the attempt to penetrate to the Niger and Tombuctoo. This opening, though foreign to any of Mr Park's former pursuits, except that of natural history, was immediately embraced by him with an ardour which showed how congenial it was to the character of his mind. Without hesitation, he offered himself for this arduous and perilous service, and being supported by the recommendation of Sir Joseph Banks, was at once accepted.

Park spent about two years in and near London, acquiring the qualifications necessary for his mission. In May 1795 he set sail, and on the 21st of June following arrived at Jillifree, near the mouth of the Gambia. After spending some months with Dr Laidley at Pisania, in acquiring the Mandingo language, he, on the 2d December 1795, departed on his grand expedition. It would be very superfluous to enter here into a detail of events so generally known, and which excited so deep an interest, as his captivity among the Moors—his almost miraculous escape—his discovery of the course of the Niger—of the African capital of Sego—his journey through Bambarra, and the train of peril and difficulty through which he effected his return. He arrived, after the length of his absence, and the

want of intelligence respecting him, had nearly extinguished all hopes of his safety. Reaching London early in the morning of Christmas 1797, he went to pass the time before breakfast in the gardens of the British Museum, where, by a singular chance, he met Mr Dickson, who embraced his friend as one returned from the grave. An extraordinary interest in his adventures was immediately excited among the African Institution, its friends, and the public in general. Major Rennell drew up an important Memoir, showing the new light thrown by his journey upon African geography, which, with an abstract of his Narrative, by Mr Bryan Edwards, was speedily offered to satisfy the curiosity of the public. In the spring of 1799 Mr Park presented the public with a full Narrative from his own pen. Major Rennell's Memoir was appended, and a considerable part of Mr Edwards's abstract was incorporated *verbatim;* upon which circumstance alone seems to have been built the rumour of that gentleman having been the actual writer of the volume. The work was read with an avidity proportioned to the novelty and importance of the information contained in it, and to the interesting and agreeable manner in which the events were narrated.

Having finished this task, Mr Park seems to have resolved to retire into domestic and professional life. In 1799, he married Miss Anderson of Selkirk, daughter of the gentleman with whom he had served his apprenticeship as a surgeon. In October 1801, he embraced an opportunity which offered of commencing a professional career at Peebles, and soon found himself in respectable practice. His situation seemed now sufficiently comfortable, being happy in domestic life, possessed of competence, and surrounded by a respectable society; but his active mind was not to be so satisfied, and was secretly panting after a higher sphere of exertion.

Important as were his discoveries, their effect had been, not to satisfy, but to excite still farther, the public curiosity. The course of the Niger through the unknown and central parts of the continent could not fail to excite peculiar interest. This was strongly felt, not only by the scientific world, but by some intelligent members of administration, who, on the conclusion of the peace in 1801, determined to fit out an expedition on a great scale to effect the discovery of the termination of this great river. In autumn 1803, Lord Hobart, now Earl of Buckinghamshire, who was then Colonial Secretary, offered the command of it to Mr Park, who, though he asked a short interval to consult his friends, seems never in his own mind to have hesitated as to its acceptance. To those who represented to him the dangers to be incurred, he urged, that the hardships attendant on the obscure exercise of his profession, his journeys to distant patients, his long and solitary rides over "cold and lonely heaths," and over "gloomy hills, assailed by the wintry tempest," would tend as effectually to shorten life as the journey now in contemplation.

Mr Park, in this new undertaking, was amply supplied with every thing which could ensure success. Thirty soldiers, and nearly the same number of carpenters and artificers, were placed under his command; arms, beasts of burden, commodities to trade with, were amply supplied; and he was empowered to draw upon the Treasury to the extent of L. 5000. Every thing, therefore, seemed to augur a still more brilliant issue to his present than to his former journey. But a dark destiny impended over it, and rendered abortive all human means and efforts.

It would be superfluous to enter into a detail of that afflicting train of events, with which the public are already but too well acquainted.* That Park perished in his voyage down the Niger, may be now considered as fully established; and we need not swell our pages with the rumours that have been circulated respecting an event no longer doubtful.

Park has been pronounced by some the first of modern travellers, and he does not seem unworthy of that high appellation. The problem of the course of the Niger, which he had the fortune to solve, was one which had involved in error almost all former geographical systems on Africa. D'Anville, indeed, had stated it correctly; but as he had not communicated the grounds upon which his conclusion rested, the opposite opinion, which represented the Niger as flowing westward, and joining the ocean by the channel of the Senegal, continued still prevalent. This point, finally decided, fixed the geographical character of the continent. In Bambarra, also, a name as yet scarcely heard of by Europeans, Park found a kingdom much farther advanced in populousness and civilization than was yet supposed to exist in the heart of Africa.

Mr Park's literary, though not equal to his active qualifications, were yet respectable. Notwithstanding his knowledge of botany, he cannot be considered as a scientific traveller. We see not in him that varied and splendid science which, in Humboldt, illustrates and adorns, though it sometimes overlays the main subject. But with regard to the general aspect of nature, and the forms of human society, his observations are careful, accurate, and judicious. Nothing can be more lively than the idea which we receive from him of the African forests and deserts, the cities of Bambarra, the stream of the Niger, and the regions watered by it. The spirit, joined to the unpretending simplicity of his narrative, has rendered

* The Narrative of this journey was published in 1815, in 4to, with a very interesting biographical Memoir and Preface, by Mr Wishaw. It may not be amiss to notice here a singular oversight in Park's Journal, lately observed by M. Walckenaer. A 31st day is counted in April (p. 7); and as all the days before and after are accounted for, there can be no doubt that all the following dates are one day behind. This, as Mr Bowdich has shown, is not so trifling an error as it at first sight appears; for a false declination being thus taken, an error, greater or less, and sometimes not inconsiderable, is committed in the calculation of all the subsequent latitudes.

his work one of the most popular of its kind in the English language.

Mr Park's bodily frame was well fitted for the arduous enterprises which he undertook. He was six feet high, his limbs well proportioned, and his whole frame active and robust. His countenance was prepossessing, and his manners retained always their native plainness and simplicity. This was combined with a natural coldness and reserve, which rendered his conversation less interesting than was expected by those who considered his general talents and extensive opportunities of observation. His conduct in all the relations of private life was highly exemplary. He left a widow, three sons, and a daughter. (B.)

PAUW (Cornelius de, sometimes called Nicolas), a moral philosopher and historian, born at Amsterdam in 1739, is better known as the uncle of the revolutionist Anacharsis Clootz, than by the ancestors from whom he was descended: they are, however, reported by his nephew to have distinguished themselves in the revolutions of Holland in the sixteenth century.

It appears, upon the same authority, that his name was Cornelius, and not Nicolas, but that he was not related to Cornelius de Pauw, the critic, and the rival of Dorville; and that it was upon the marriage of his sister to Clootz's father, that he obtained, through the interest of his brother in law, a Catholic canonicate at Xanten, in the territory of Cleves. He was afterwards appointed reader to Frederic King of Prussia, perhaps as an advocate of the new doctrines and principles which that sovereign was disposed to patronise; but he is said to have declined the offer of the place of an academician of Berlin, and a bishopric at Breslau. His attacks on the Jesuits, whom he accused of gross misrepresentation and exaggeration in their historical and geographical memoirs, made him unpopular with the Catholic clergy, though his learning and talents commanded a certain portion of their respect. He was simple in his manners, and somewhat negligent of his appearance; the close of his life was imbittered by a tedious and painful disease, and he died the 7th of July 1799.

1. His principal publications are his *Recherches sur les Américains*, 2 v. 8. Berl. 1770; ed. 2, 1772; a work intended to show the "degraded state of the savage Americans," and forming a contrast to the speculations of some contemporary writers of celebrity. 2. *Défense des Recherches*, 8. Berl. 1771.

3. *Recherches sur les Egyptiens et les Chinois*, 2 v. 8. Berl. 1773. *Philosophical Dissertations on the Egyptians and Chinese*, translated by Captain J. Thomson, 2 v. 8. London, 1795. The investigation was undertaken, he observes, to show that "no two nations ever resembled each other less than the Egyptians and the Chinese;" and it must be admitted that he has sufficiently established his proposition. There is, indeed, one argument that he has employed, which appears to be founded on a mistake of the Greek historians of Egypt, who have asserted that the Egyptians had long been in the use of alphabetical characters; and the want of any alphabet among the Chinese, is stated by M. de Pauw as affording a marked distinction from the Egyptians. There is, however, scarcely a shadow of resemblance in the particular hieroglyphical characters employed by the two nations, though the general system of beginning with a representation of a visible object, and departing, more and more, by degrees, from the fidelity of the delineation, must necessarily have been common to both. But it so happens, that out of about 70 Egyptian characters, which are compared by the Jesuits and Dr Morton with the Chinese in the *Philosophical Transactions* for 1769, there are about 20 of which the sense has been ascertained with tolerable accuracy in the Article Egypt of this *Supplement*; and of these there is only one that happens to have been rightly determined by the comparison with the Chinese, excepting two or three which are obviously mere pictures, as the Moon and a Bow. There is also a figure of a chain, among the old Chinese characters, which agrees remarkably in its form with the Egyptian hieroglyphic employed as a copulative conjunction; and there is a still more striking coincidence, which M. Jomard has noticed, between the Egyptian and Chinese characters for a thousand, both of which he derives from the seed vessel of the lotus, as containing a multitude of seeds; and if the older Chinese characters be found to preserve this resemblance as perfectly as they ought to do, it must be confessed that the suspicion of a common origin will be much strengthened by the argument. Both the Egyptians and the Chinese were condemned, M. de Pauw observes, "to an eternal mediocrity;" and the weight of this observation is certainly not diminished by any thing that has lately been inferred from the study of the hieroglyphics of the stone of Rosetta.

4. There are several papers of M. de Pauw on antiquarian subjects in the *Memoirs of the Society of Cassel*, and one in particular *On the Temple of Juno Lacinia*, Vol. I. 1780.

5. *Recherches sur les Grecs*, 2 v. 8. Berl. 1787. *Philosophical Dissertations on the Greeks*, translated by Thomson, 2 v. 8. Lond. 1793. The work is principally devoted to the Athenians, among whom their boasted liberty is shown to have been confined to a very small number of citizens, who tyrannized over the rest of the inhabitants of their country. The Lacedæmonians, the Aetolians, the Thessalians, and the Arcadians, are separately discussed, but considered as comparatively contemptible; the Lacedæmonians in particular, and their successors, the Mainotes, are treated with great severity, as a worthless race of dishonourable vagabonds. The athletic education of the Athenians is, however, highly applauded, from a visionary theory of the importance of the physical perfection of the body to the operations of the mind. An edition of the author's three principal works appeared at Paris, in seven volumes octavo, 1795.

[Dorsch, *Chardon-la-Rochette*, and Clootz, *Magaz. Encycl.* 1799. An. V. Vol. II. Widdigen, *Westph. Nationalk.* 1801, p. 215. *N. Allg. T. Bibl.* LXXIV. p. 77. Denina, *Prusse Littéraire*, III. *N. Dict. Hist.* IX. 8. Par. 1804. Chalmers's *Biographical Dictionary*, XXIII. 8. Lond. 1815.]

(E. O.)

Peebles-shire.

PEEBLES-SHIRE, or TWEEDDALE, a county in Scotland, situate between 55° 24′ and 55° 50′ north latitude, and between 2° 45′ and 3° 23′ west longitude from Greenwich. It is bounded on the north by Mid-Lothian or Edinburghshire; on the east by the county of Selkirk; on the south by Dumfries-shire; and on the west by Lanarkshire. Its greatest extent from north to south is about 30 miles, and its greatest breadth from east to west about 22; the contents being 229,778 English acres; of which only about a tenth part is fit for cultivation. It is divided into sixteen parishes, twelve of which form the presbytery of Peebles, and four belong to that of Biggar, all under the synod of Lothian and Tweeddale.

Situation.

Extent and Divisions.

Surface, &c.

The surface of this county is hilly, and towards the south mountainous, several of the high grounds in that quarter, such as Hartfield, Harstane, Broadlaw, and Dollarlaw, being from 2800 to nearly 3000 feet above the level of the sea. The general elevation of the pasture lands is about 1200 feet; yet, with few exceptions, the hills are covered with green herbage, heath being almost confined to a few of the highest ridges on the south-east. On the banks of its streams are many pleasant and fertile spots; but from the want of wood, the general appearance is naked and uninteresting, except about the seats of the proprietors, where considerable plantations have been made, extending in all to more than 2000 acres. The soil of the cultivated land, lying chiefly on the sides of the lower hills and the banks of the streams, is, for the most part, a light loam, with clay, moss, and moor, on the high grounds. Coal and limestone abound in the parishes of Linton and Newlands, on the north side of the county, and in the latter, ironstone; in the same quarter red and white sandstone is wrought for sale, and the parish of Stobo, on the Tweed, has long furnished a good kind of slate, much of which is carried to the adjacent counties. The river Tweed, from which this district is often called Tweeddale, rises from a well of the same name, in the parish of Tweedsmuir in the south-western extremity of the county, about 1500 feet above the level of the sea, and flowing first north-east and then east, dividing the county into two nearly equal parts, passes into Selkirkshire at Gatehaup-burn, after a winding course of about 36 miles. The Annan and the Clyde have their source in the same quarter. Of the other streams, here called *waters*, the most considerable are Biggar, Lyne, Peebles or Eddlestone, Leithan, Mannor, and Quair, which fall into the Tweed; and the North and South Esks, which pursue their course into Mid-Lothian. The lakes or lochs are St Mary's, Waterloch, and Slipperfield. These, as well as the rivulets, abound in the common fresh-water fish, and most of the streams are occasionally frequented by salmon; but salmon are not found in such numbers, even in the Tweed within the bounds of this county, as to afford a fishery that will pay rent.

Tweed.

Climate.

The climate of Peebles-shire, owing to its elevation and want of shelter, is perhaps more rigorous than that of the other southern counties of Scotland. Cold easterly winds prevail in spring, which greatly retard vegetation; and frosts often occur in summer, which injure the potatoe and other crops; while the winters are frequently so severe as to destroy turnips, and the snow lies so deep and so long as to occasion great loss among the flocks.

Peebles-shire.

Estates.

Peebles-shire, in 1811, was divided into about 80 estates, many of them large, but not valuable in proportion. The valuation of the whole is L. 51,937, 13s. 10d. Scots; and the real rent, as assessed to the property-tax that year, was, for the lands, L. 57,382 Sterling, and for the houses L. 2568. Two-thirds of the estates are valued under L. 500 Scots; a sum which may indicate pretty nearly their present yearly value in Sterling money, and little less than two-thirds of the whole is entailed. In the same year the number of freeholders entitled to vote in the election of a member for the county was 39. Many of the proprietors, among whom, there were lately five noblemen, have seats distinguished either for their antiquity or their beauty; but the Earl of Traquair is the only nobleman who now resides in the county. Of the other seats the most considerable are Darnhall, Lord Elibank; Drummelzier, Hay; Magbiehill, Montgomery; Neidpath Castle, the heirs of the late Duke of Queensberry; and Whim, Montgomery.

Seats.

Farms.

As this is almost exclusively a pastoral country, the farms are in general large, most of them from 1000 to 4000 acres. On the arable land they are small, the greater number below 100 acres. These are in general held on leases for 19 years, as in other parts of Scotland. Taking the extent and rental as before stated, the average would be nearly 5s. the English acre. This is chiefly derived from live stock, especially sheep, of which there may be about 120,000. Most of these are still of the black-faced heath variety, sometimes called Tweeddale sheep, from the name of the county, or Linton sheep, from the name of a village on the north side of the district, where great fairs are held for the sale of them. The Cheviot breed, however, which bears a much more valuable fleece, has established itself on many of the lower hills. The crops are the same as in other parts of Scotland, except that wheat is cultivated only upon a very small scale. A variety of oat, called the *red oat*, and sometimes the *Magbiehill oat*, from its being first cultivated here on that estate, is well adapted to high and exposed situations; both because it ripens earlier than the common kind, and is less liable to be beat out by wind, while on good land it is found to be highly productive.

Towns and Villages.

Peebles, a royal burgh, containing, in 1811, about 2200 inhabitants, is the only town in the county. The villages are Linton, Skirling, Eddlestone, Broughton,—at all of which fairs are held, chiefly for the sale of live stock, and for the hiring of servants,—and Innerleithen, where a woollen manufactory has been established. There is no other manufacture within the county, if we except that of stockings, carpets, and flannels, all upon a small scale, carried on in the town of Peebles, where there is also an extensive brewery. Peebles-shire, therefore, has little to offer in exchange for the commodities which it requires but its raw produce; chiefly sheep and wool.

The county sends one member to Parliament, and

Peebles-shire ‖ Pembroke-shire.

the town of Peebles joins with Selkirk, Lanark, and Linlithgow, in electing another for the Scottish burghs. The following abstract shows the population in 1801 and 1811.—See the general works quoted under the former Scottish counties, and Findlater's *View of the Agriculture of Peebles.* (A.)

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
1,682	1,843	64	4,160	4,575	2,010	886	5,839	8,735

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
1,740	1,961	72	4,846	5,089	875	610	476	9,935

Extent and Boundaries.

PEMBROKESHIRE, a maritime county of South Wales. It forms a peninsula at the south-west corner of the principality, and is surrounded by the sea every where but on the eastern side, where it is bounded by Carmarthenshire, and by Cardiganshire. Its shape is very irregular, which makes it difficult to ascertain its exact extent. Its extreme length is thirty, and its extreme breadth twenty-seven miles. Its area is estimated, but with no decided accuracy, at 575 square miles.

Face of the Country.

It is generally an undulating country, composed of plains, with hills of no great elevation, except in the northern part, where a range of mountains is stretched out to the extent of nine or ten miles; the loftiest points of this group are Precelly Top, 1754 feet, and Brennin-Vaur, 1285 feet above the level of the sea. Few of the hills in the other parts of the county attain a greater height than 290 feet. As the greater part of the country is destitute of woods, it has a bare and bleak appearance, except in the valleys, where the numerous brooks that flow through them impart a pleasing verdure to the bordering meadows.

Bays, Rivers, and Estuary.

The most considerable rivers are the Eastern Cleddaus, which forms at first the dividing line between this county and Carmarthenshire; and the Western Cleddaus, which traverses a considerable portion of Pembrokeshire. These two rivers unite, and form the admirable estuary of Milford Haven, which is considered to be the best harbour in the British islands. It is sufficiently capacious to contain the whole navy of England; is so completely sheltered as to be secure from all winds; has good holding ground, and competent depth of water. These natural advantages have induced the Lords of the Admiralty to establish a dock-yard on its banks, where ships of the line and frigates are built, and where the town of Haberstone has in a few years sprung up, and grown to considerable importance. It is the place whence the packets for the south part of Ireland sail, and to which, on that account, numerous passengers resort. The other rivers are of inconsiderable note; namely, the Newgall, the Solva, the Alan, the Gwayn, the Nevern, the Cuch, and the Teivi. Besides Milford Haven, St Bride's Bay and Fishguard Bay deserve notice, as affording secure anchorage for large ships, and possessing good landing-places. This circumstance induced the government of France, in the year 1797, to land some troops from two frigates under General Tote, which in a few days surrendered to the inhabitants, who hastily collected with such arms as presented themselves. It was generally supposed that the men were criminals of the worst description, whom the French took this extraordinary method of discharging from their prisons.

The soil of the county is generally a red loam, in many parts resting on a calcareous subsoil, and admirably adapted for the growth of corn. In some places the surface is covered with porous stones, which are supposed to imbibe and retain the salt from the saline air, and to render the land highly prolific. The principal grain consists of wheat, barley, and oats, but in some parts of the county rye is extensively cultivated. The modes of cultivation are commonly the same as prevailed in remote ages in this island; that is, growing wheat, barley, and oats in succession, till the land was so exhausted as to yield no increase, when it was suffered to return to its natural state, under the idea of recovering itself by rest.

Pembrokeshire.

Very little attention is given to the preservation of manure; the barns and farming erections are very badly constructed, and the agricultural implements, especially the ploughs, are of a rude and antique form. Such is the description of the greater part of the agricultural state of the country, but there are splendid exceptions, affording specimens of improvement that would have been more extensively followed, but for the general depression of agriculture, which has been experienced within the last few years. The size of the farms varies from fifty to five hundred acres; the average extent of them is estimated to be about two hundred: some of the occupiers are annual tenants, but many hold from the lords of manors by leases for three lives at an agreed rent, but without any fine on the renewal of a life, as is customary in England, and on the lands in Pembrokeshire belonging to the church.

Cattle.

The black cattle of this county are of an excellent race, and are annually distributed over the south of England in droves, which travel from fair to fair, till the whole are sold. They are commonly sent to market when they are in calf the first time. Some valuable horses are bred here. The sheep are small, and yield little wool, but the mutton is very highly esteemed.

Minerals.

At no very remote period, silver was found in the parish of St Elwys, or St Bride's Bay. The mine, which was discontinued in the reign of Queen Elizabeth, was resumed a few years ago, but not with such success as to induce perseverance. Some excellent lead ore is found on the banks of the Tave, but the mines are not worked with any degree of spirit. The most important production of the mines is coal. It is confined to a district of narrow extent on the southern side of the county. The veins lie near the surface, and the quality is not very good. The inhabitants use the small coal mixed with clay, and formed into balls; it is sulphureous, and highly offensive to strangers.

Manufactures and Commerce.

The manufactures of this county are very inconsiderable. Some speculators, indeed, were induced, by the excellent streams of water, to erect mills for spinning cotton, and for making tin plates; but these schemes, though conducted with much spirit, were found to be unprofitable, and finally abandoned. The principal commerce of the county is a coasting trade, and the conveyance of coals from Tenby to the opposite shores of Somerset, Devon, and Cornwall, where they are principally used for burning lime, and drying malt. Under the auspices of the late Honourable Charles Greville, and with the sanction of a special act of Parliament, some American fishermen formed an establishment at Milford for the purpose of carrying on the southern whale fishery, upon the plan of the crew being sharers with the owners in the result of the fishing, as is practised in the United States. The concern was conducted with success for several years, but has been recently abandoned from various circumstances, none of them connected with the local position, which was ascertained to be favourable.

Language.

The inhabitants are of two distinct races. If a line be drawn through the whole county, cutting through the centre of the town of Haverfordwest, it will be found that on one side of the line nothing but English is spoken, and on the other side only Welsh. This is so definite, that in the town of Haverfordwest, the one language is spoken in the upper and the other in the lower part of it; and there are two markets, one frequented by the English, the other by the Welsh peasantry. The part where the English live, called commonly "Little England, beyond Wales," was originally peopled by a colony of Flemings, who have kept themselves distinct since the first colonization. They are allowed to speak the English language with more purity than is to be found among the lower classes in any other part of the island.

Divisions and Representatives.

Two members are returned to Parliament from Pembrokeshire; one for the county, and one for the boroughs of Pembroke, Tenby, and Wiston. The divisions are into seven hundreds, which contain one cathedral, one hundred and forty-five parishes, and several chapelries.

St David's.

St David's, the see of a bishop, is a miserable collection of cottages, in the midst of traces of ancient, extensive, and numerous buildings. The object deserving of most notice is the cathedral, whose antiquity is very great, having been originally built about the year 1180, and enlarged in 1280 and 1328. This venerable pile has been much repaired and improved by the prelate who at present fills the see. The bishop's palace is a magnificent pile, not far from the cathedral, on the opposite side of the river Alan. It was originally a quadrangular building of great extent, of which at present only one side remains entire.

Antiquities.

Among the ancient buildings in this county, the most remarkable are, Carew Castle on a creek of Milford Haven; Manorbeer, the mansion of the Barri family, of which Giraldus Cambrensis was a member; and Killgarran, on the river Tyvy, whose massy towers and fragments of bastions present a most imposing spectacle.

Seats.

The picturesque beauties of this county, and the mildness of the air, have induced many gentlemen to select it as the place of their residence, and the number of their seats is considerable; among them are Picton Castle, Lord Milford; Hen Gastell, Thomas Stokes, Esq.; Slebeck Hall, N. Phillips, Esq.; Oriclton, Sir John Owen, Bart.; Johnston, Lord Kensington; Trecoon, J. F. Barham, Esq.; Fynonean, John Colby, Esq.; Stockpool Court, Lord Cawdor; Begelty Hall, James Child, Esq.; Lawrenny, Hugh Barlow, Esq.; Tal y Bort, John Meares, Esq.; Payston, (the late) General Picton; Plâs Newydd, Sir Watkin Lewis; and Pentree, Dr Davies.

Population.

The population of the county, by the census of 1811, was 60,615 persons, viz. 27,453 males, and 33,162 females; the militia are not included. The principal towns are Haverfordwest, with 3093 inhabitants; Pembroke, 2415; St David's, 1816; Tenby, 1176; Fishguard, 1608; Newport, 1487, and Hubberston, 754.

See Malkin's *South Wales*, and Fenton's *Pembrokeshire*. (W. W.)

PENDULUM.

WHEN a solid and heavy body of any form and description is suspended from an axis fixed horizontally, and round which it can turn with freedom, or at least with a very slight degree of friction; if we withdraw it, however little, from the position of equilibrium at which it naturally places itself when at rest, and then abandon it to itself, the force of gravity, which is now no more destroyed by the resistance of the axis of suspension, brings back the body towards its primitive position of equilibrium with a velocity continually accelerated. When it reaches this position, the accelerating force ceases for a moment to act on it, but the body continuing to move in consequence of the velocity already acquired, rises on the other side of the vertical line, and continues rising until the constantly increasing force of gravity destroys its velocity—then it stops for an instant, and again yielding to the continued action of gravity, to which there is now no more any opposition, it again falls with a motion exactly similar to that which it had when it began to descend from the opposite side of the vertical. It returns then, in the same manner, to its primitive position of equilibrium, passes it, and reascends on the opposite side of the vertical to the point where its velocity is destroyed anew; after which it again begins to descend, and again to remount; and the oscillatory motion which results from these alternations only ceases in consequence of the resistance of the air and the friction of the axis, which gradually reduce it to nothing.

An apparatus of this kind is termed a *pendulum.* The oscillations of pendulums can be calculated completely, and with perfect rigour, by the principles of mechanics, when they are supposed to take place in a vacuum, and round an axis, which presents no friction. The results in regard to this imaginary case are so much the more important to be known, as in the real experiments we always endeavour to approach it as near as possible, by combining to the utmost every circumstance which can tend to prolong the duration of the pendulum's motion. These are the results, then, which it is proper to present first in order, as they exhibit a first approximation to every motion of this kind, which can be realized.

In this simple case, whatever be the form of the body which constitutes the pendulum, provided that it remains invariably constant, all the successive oscillations have equal amplitudes, and are also of equal duration among themselves, so that the motion, once begun, never ceases to go on. In the case of oscillations with different amplitudes, the duration is in general unequal, but this inequality diminishes in proportion as the amplitudes become less, and it ceases altogether at the limit where they become infinitely small; so that all the oscillations made with amplitudes, which, in a physical sense, may be reckoned infinitely small, are sensibly of equal duration.

In regard to the nature of the motion in each oscillation, it is absolutely the same for every body, whatever be its form, and we may always consider it as identical with that of a pendulum formed by a material gravitating point suspended at the extremity of a thread, supposed to be inflexible and without weight. Let l (Plate CIX. fig.1) denote the ideal length of such a pendulum, which is called a *simple pendulum.* Let m be the mass of an oscillating body with which we wish to compare it, and which we shall call, in opposition to the other, a *compound pendulum.* From the centre of gravity of this body, denoted by G, conceive a perpendicular SG drawn to the axis of suspension, and call h the length of this line. If we multiply each element of the mass m by the square of its distance from the same axis, and denote the sum of the whole by C, the product C thus formed will be what is called in mechanics the momentum of inertia of the body m relatively to the axis in question. In order that the motion of the simple pendulum SP be exactly isochronous with that of the body m, it is sufficient that we have the equation $l=\frac{C}{mh}$, and besides this, that the lines SP and SG have at any one instant an angular velocity equal at the same distance from the vertical. This last condition will be fulfilled if, for example, at the beginning of the motion the lines, SP, SG, are equally distant from the vertical, and that the simple and compound pendulum be then abandoned together to the action of gravity, or be driven with equal velocities in the plane of their oscillations. The simple pendulum will then accompany the compound one in all its successive excursions, and its direction will always coincide with the line SG drawn from the centre of gravity of the body m, perpendicular to the axis of suspension. The length l being ascertained by this formula, we can lay it off on the line SG, setting out from the axis of suspension S, and the point P, where it terminates, is called the *centre of oscillation* of the body m.

The initial conditions above stated can be always established, and the analytical value of l is also always real. For every given compound pendulum, then, we can always assign a simple pendulum, which is isochronous with it, and of which the motion is absolutely similar to that of the line SG. By means of this substitution, we have nothing more to consider or to compare, but the different lengths of the simple pendulums, and it then only remains to ascertain the mode in which such pendulums perform their oscillations.

To do this in the simplest manner possible, let us conceive that the arc ZP (Plate CIX. fig .2) is half the extent of the oscillations round the vertical SZ, and suppose that the pendulum arrived or placed in this position is there abandoned to the sole action of gravity without any initial velocity of impulsion. Call α

the angle PSZ, and denote by g the intensity of gravity measured by the double of the space which heavy bodies describe at the place where the experiment is made, when they fall freely in a right line during the unity of time. Then denoting always by l the length of a simple pendulum SP or SZ : the time T of its whole oscillation in the arc PZP′ or PP′ will be expressed by the following series :

$$(1.)\ T=\pi\sqrt{\frac{l}{g}}\left\{1+\left(\tfrac{1}{2}\right)^2\sin^2\tfrac{1}{2}\alpha+\left(\frac{1.3}{2.4}\right)^2\sin^4\tfrac{1}{2}\alpha+\left(\frac{1.3.5}{2.4.6}\right)^2\sin^6\tfrac{1}{2}\alpha+\ldots\ \&c.\right\}$$

π being the ratio of the circumference of the circle to its diameter, or 3.14159.

If, besides, we denote the velocity of the pendulum in any point of its oscillation by V, θ being its angular distance from the vertical, we have

$$(2.)\ V^2=2gl\,(\cos\theta-\cos\alpha)$$

or, what comes to the same thing,

$$V^2=4gl\sin\tfrac{1}{2}(\alpha+\theta)\sin\tfrac{1}{2}(\alpha-\theta).$$

These formulæ will still serve if the pendulum, instead of falling freely from the extremity of the arc, receives there an initial velocity expressed by V′, provided always this velocity is within the limits which permit the oscillatory motion to take place. If this be the case, indeed, it will be sufficient to consider the pendulum as setting out with an initial impulse from another angular distance, α'. Then it will be necessary that this unknown distance α' satisfy instead of α, the general equation of the velocities, and that α becomes in it θ, which gives

$$(3.)\ V'^2=2gl\left\{\cos\alpha-\cos\alpha'\right\}$$

The half amplitude α' of the oscillations being the only unknown quantity in this equation, will be thus determined, and their duration will be then obtained by the equation (1), but putting in it α' instead of α. This same substitution made in the equation (2) will give

$$V^2=2gl\,(\cos\theta-\cos\alpha')$$

for the velocity in any point whatever of the oscillation. But these transformations are only possible when the equation (3) gives for α' a real arc, and consequently for cos α' a value comprehended between +1 and —1. We may easily conceive, that, when the cos α' exceeds these limits, it is because the velocity of impulse V′ exceeds the greatest velocity of the fall which the pendulum can acquire in a circle of a radius l, even supposing it to fall from the very summit. It is evident, indeed, that the oscillatory motion can then no more produce such a velocity, and we know also that, in that case, it will change into a continued motion of rotation. If we exclude this circumstance, the formulæ (1) and (2) will determine generally every particular regarding oscillatory motions. When the amplitudes of the oscillations become so small that we can, in the series (1), neglect all the powers of $\sin^2\frac{1}{2}\alpha$, compared with the unity which precedes them, we will have simply $T=\pi\sqrt{\frac{l}{g}}$.

Now, the angle α entering no more into the value of T, it appears that its value will have no influence on it; that is to say, that *for the same pendulum moved in a vacuum, all the oscillations which are performed with amplitudes infinitely small, are of equal duration.*

In actual experiment, the oscillations can never be altogether infinitely small, but we may take care, at least, to confine them within amplitudes so limited, that the angle α has a very small value. We have then an approximation perfectly sufficient in limiting the series to the term which contains the square of the $\sin\frac{1}{2}\alpha$. We may then, in the same order of approximation, substitute $\frac{1}{4}\sin^2\alpha$ for $\sin^2\frac{1}{2}\alpha$; and the series (1) being thus limited to its two first terms, gives

$$T=\pi\sqrt{\frac{l}{g}}\left\{1+\frac{1}{16}\sin^2\alpha\right\}$$

α being always the half amplitude of the oscillation.

We have seen above, that, by supposing the simple pendulum l isochronous with the compound pendulum of the mass m, we have

$$l=\frac{c}{mh},$$

c being the momentum of inertia of the mass m, relatively to the axis of suspension. But if we call c' the momentum of the same mass, relatively to an axis parallel to the preceding, and passing through the centre of gravity G, we find, by mechanics, that the quantities c, c' have between them the following relation :

$$c=mh^2+c'.$$

This value of c being substituted in the expression of l, gives evidently

$$l=h+\frac{c'}{mh}.$$

Now, when h is given, this expression only furnishes one value of l; that is to say, a single length for a simple pendulum isochronous with the mass m. But if l be given, then there are two values of h, which give the same value to l; and these are deducible from the preceding equation, by taking h in it as the unknown quantity. If we denote these two values of h by h' and h'', it is easy to see that their sum is l, and that thus the first being SG (fig. 1), the second will be PG. If, then, after having placed the axis of suspension in S, we place it in P, that is, in the centre of oscillation itself, preserving it always parallel to its first direction, the oscillations performed round the axis P will be of the same duration as those performed round the axis S, provided always that in both cases the amplitudes of the oscillation, as well as the initial velocities, are equal. This remarkable theorem we owe to Huygens.

It is easy to extend it to one much more general. In all solid bodies, whatever be their figure, we may draw through the centre of gravity three rectangular axes, termed in mechanics *principal axes*, and which possess several properties extremely remarkable. Let the momentum of inertia of the mass m relatively to these axes be denoted by A, B, C. Then, if we consider any axis of suspen-

sion of which the distance from the centre of gravity is expressed as above by h, and which forms with the preceding certain angles, X, Y, Z,—it is shown, in mechanics, that the momentum of inertia c'', relatively to this axis, can be expressed in the following manner:

$$c'' = mh^2 + A\cos^2 X + B\cos^2 Y + C\cos^2 Z;$$

and this value being substituted in l, instead of the letter c, gives

$$l = h + \frac{A\cos^2 X + B\cos^2 Y + C\cos^2 Z}{mh}.$$

If, now, the axis of suspension be given along with the distance h, this expression gives but a single value for l; but if we regard l as given, and constant, then there arises between the angles X, Y, Z, and the distance h, a simple relation, which we can satisfy in an infinity of different ways, so that there result as many different axes of suspension, which are all isochronous with each other. To be sensible of the extensive application of such solutions, let us transform the preceding relation into one with rectilineal co-ordinates. Let x, y, and z, be such co-ordinates directed rectangularly, according to the three principal axes of the mass m, and having their common origin at the centre of gravity of this mass, the axis of suspension relatively to these co-ordinates will have its equations of the form

$$(4.)\quad x = az + \alpha \quad y = bz + \beta,$$

a, b, α, β, being four constant indeterminate quantities, depending on their position in space. We have, besides, by the well-known theorems of analytical geometry,

$$\cos X = \frac{a}{\sqrt{1+a^2+b^2}},\ \cos Y = \frac{b}{\sqrt{1+a^2+b^2}}$$

$$\cos Z = \frac{1}{\sqrt{1+a^2+b^2}},\ \text{and, lastly, } h = \frac{\sqrt{\alpha^2+\beta^2}}{\sqrt{1+a^2+b^2}}.$$

By substituting these values in the general expression of l, it becomes

$$(5.)\quad l = \frac{\sqrt{\alpha^2+\beta^2}}{\sqrt{1+a^2+b^2}} + \frac{Aa^2+Bb^2+C}{m\sqrt{\alpha^2+\beta^2}\sqrt{1+a^2+b^2}}.$$

By supposing l constant, this relation, combined with the equation (4), will characterise the isochronous axes: but as this combination only furnishes three equations, while there are four constant indeterminate quantities a, b, α, β, in the position of the axis, it hence appears that we may still assume at pleasure an additional condition among the quantities themselves, after which, by eliminating them, we shall have in $x\,y\,z$, the equation of a surface on which will be found the isochronous axes fitted to satisfy the condition prescribed.

Having thus made known the laws of oscillatory motion, in a vacuum and round an axis altogether free from friction, let us now consider them in a feebly resisting medium like air, and supposing a slight degree of friction round the axis, such as is invariably the case in the experiments.

In the first place, whatever be the nature of the physical process by which the two causes operate, their definite effect will always be to retard the pendulum, according to a certain function of the velocity. But whatever be the form of this function, provided it be such as to become nothing when the velocity is nothing, which is an essential condition of the kind of obstacles it is designed to express, we may always assign a simple pendulum which, moving with the same laws of friction and resistance, will be exactly isochronous with the compound pendulum we are considering; and what is very remarkable, the length of this simple pendulum is exactly the same as it would be if the oscillations were performed in a vacuum, and consequently the same as that of which we have given the expression above. Thus the centre of oscillation of solid bodies such as we have defined it, has in each of them a situation independent of the medium in which they move, and of the resistances of every kind which their motions may suffer. This important proposition was first demonstrated by Clairault.

Now, for the simple pendulum, as well as for the compound one which accompanies it, the resistance of the air and the friction of the axis diminish continually the extent of the arcs in which the successive oscillations are performed; but it happens, from a circumstance well worthy of remark, that when this retarding force is very slight, and acts with continued and equal effect on both sides of the vertical, the duration of the oscillations are not altered on this account. For, although the resistance which the pendulum suffers must retard, no doubt, its fall, and consequently prolong its duration in each half-oscillation in descending; yet in each half-oscillation, in ascending, this same cause accelerates the extinction of the velocity, and rather brings on the instant when this half-oscillation is terminated. And whatever be the mathematical law of the motion thus performed, if the amplitudes of the successive oscillations diminish very slowly, which always takes place when the body put into oscillation has a very considerable density relative to that of the air, and if we make it perform vibrations only of very small extent, and round an axis of suspension so worked as to present but a slight degree of friction, then the motion of the pendulum presents a succession of velocities almost exactly similar in each descending half-oscillation, and in the ascending half which follows it. The alterations produced in these velocities by the friction and the resistance of the air, are then almost equal, so that their effects are almost exactly compensated in the actual observations. Hence it follows that the isochronism of small oscillations, though altered in each particular half-oscillation, is still found to subsist in the total oscillations, notwithstanding of the friction of the axis, and the resistance of the air, provided always that these two forces are rendered so feeble as to have but a very gradual influence on the motion. This is at least proved by experiment; for, when a compound pendulum of any form whatever oscillates in the air round a suspension, so free that the decrease of its vibrations goes on with great slowness, if we observe the amplitudes of these vibrations at intervals so near each other, that their absolute diminution is inconsiderable, and apply to the number of oscillations performed during this interval, the reduction

of amplitude calculated according to the mean value of the arcs thus observed; the number of oscillations corrected and reduced in this manner to the case of amplitudes infinitely small, is also found invariably the same for the same pendulum, at least with all the degree of exactness admitted by physical experiments; which shows that the correction of the amplitude is the only one which the oscillations require in order to reduce the motion of the pendulum to a uniformity quite mathematical. This spontaneous compensation, which is produced in the effects of the resistance of the air on the two descending and ascending half-oscillations, had first been remarked and pointed out by Newton in his *Principia,* Lib. II. Prop. XXVII. Theor. XXII. Coroll. 2. He even gives a rigorous demonstration of it in Prop. XXVI. and XXVII. for the case of a resistance proportional to the two first powers of the velocity—the motion being then in the cycloid. M. Poisson has given the analogous demonstration for a circular motion in the seventh volume of the *Journal de l'Ecole Polytechnique.* These demonstrations, however, only apply to that part of the resistance which arises from the direct impulse with which the moving body strikes the aërial particles, supposing these particles quite removed after the stroke, and consequently without regard to the peculiar agitation which their displacement produces in the medium itself. But, as Newton remarks in the corollary above cited, the descending half-oscillation, which is performed with a motion continually accelerated, must, on this account, excite a resistance in a slight degree stronger than the half-oscillation ascending, which goes on with a motion continually retarded; because, in this second case, the aërial particles struck by the pendulum may fly from it, and withdraw themselves from its action more easily than in the former. This diminution of the resistance in the second half of the oscillation must cause it to last a little longer than it would have done without this circumstance, and thus the time of the whole oscillation must be a little augmented. Fortunately this cause, it appears, becomes insensible in the most important experiments to which the pendulum is applied; for, in these the observations are never made but with very small amplitudes, which produce very small velocities, and these cannot excite any sensible resistance except by the direct impulse communicated to the ambient medium.

But, independent of its resistance, the air, by its mere presence, floating round the oscillating body, produces on the motion another effect, which may be called *statical,* and which must be attended to, in order to compare the observations made in different states of this fluid. As a gravitating medium, in fact, it deprives the oscillating body of a part of its weight equal to that of the volume of air which the body displaces, so that the latter, in reality, only gravitates in consequence of the difference between these two quantities. To calculate the resulting effect on the oscillations, call P the absolute weight of the body in vacuo, Δ its density, compared with that of the air in the circumstances under which we are operating. The weights of bodies of equal volume being proportional to their densities, the weight of the air displaced by the body will be $P.\frac{1}{\Delta}$, thus the apparent weight of this same body, during its oscillations, will be $P-\frac{P}{\Delta}$, so that it will be to its absolute weight as $1-\frac{1}{\Delta}$ to 1. The effect, then, will be the same as if the absolute weight P were acted on, not by the actual gravity itself, but by a force diminished in this ratio. We have only, therefore, to reduce the elements of this correction to terms that we can compare together. For this purpose, suppose that at the temperature of freezing, and under an atmospheric pressure measured by a column of mercury of 0.76 metres in height, D represents the density of the substance of the pendulum, that of the air being taken as unity. If we denote the cubic dilatation of this substance for a change of temperature equal to a centesimal degree, by c, its density at t degrees will become very nearly $D\,(1+ct)$, and if p is the atmospheric pressure at this temperature, the corresponding density of the air, according to the known law of the dilatation of this fluid, will be

$$\frac{p}{0^m.76\left(1+t.0.00375\right)}$$

Then denoting the absolute intensity of gravity, as it is exerted on the body in vacuo by g, and the apparent force with which it really moves the body in the air by g', we shall have

$$g'=g\left\{1-\frac{p}{0^m.76(1+t.0.00375)(1-ct)D}\right\}$$

To illustrate the use of this correction, let l' represent the length of a simple pendulum, which performs its oscillations in the time T', under the influence of the apparent gravity g', and, with the amplitude $2\alpha'$, we shall have,

$$T'=\pi\sqrt{\frac{l'}{g'}}\left\{1+(\tfrac{1}{2})^2\sin^2\tfrac{1}{2}\alpha'+\ldots\ldots\text{\&c.}\right\}$$

In the same manner, if we call l the length of a simple pendulum, which makes its oscillations in the time T, under the influence of gravity g, and, with the amplitude 2α, we shall have,

$$T=\pi\sqrt{\frac{l}{g}}\left\{1+(\tfrac{1}{2})^2\sin^2\alpha+\ldots\ldots\text{\&c.}\right\}$$

If now we wish the two pendulums to oscillate with equal amplitudes, we have only to make $\alpha=\alpha'$; if we wish, also, to have their times of oscillation equal, we have only further to suppose $T'=T$, then the two preceding expressions being equal to each other, we obtain $\frac{l}{g}=\frac{l'}{g'}$, and $l=l'.\frac{g}{g'}$, from which we can calculate l, when we know from observation l' and $\frac{g}{g'}$.

As the density of the solid mass of the pendulum is usually very great, compared with that of the air, D is a very considerable number, so that this correction is always very small. Bouguer appears to have been the first philosopher who made use of it, as appears by his work on the figure of the earth. But before him Newton was well aware of the necessity of paying attention to it, as we may conclude even from the enunciation which he gives to the propositions regarding the resistance of the air above alluded to. For he there compares the motion of the pendulum, affected by this resistance, to that which would take place in *a medium of the same specific gravity, and which would present no resistance.*

Having thus explained in general the mathematical laws of the motion of the pendulum, whether in the air or in vacuo, we shall now describe the principal applications which have been made of them in physical science. These are, 1st, The measurement of time. 2d, The estimating of the resistance of fluid media. 3d, The comparison of the intensities of gravity on different parts of the surface of the terrestrial spheroid, from which certain positive conclusions have been drawn regarding the figure of a spheroid, as well as the arrangement, and the density of the strata of which it is formed.

The first idea of employing the pendulum as a measure of time is due to Galileo; and it occurred to him when he was observing the apparent isochronism of the small oscillations of suspended bodies. But the variation in the length of these oscillations, in proportion as the resistance of the air diminishes their amplitude; the necessity of frequently renewing, by a new impulse, the motion which this resistance was destroying; and, lastly, the tedious necessity of following, and counting directly the oscillations one by one, during the whole interval that is to be measured, these proved serious obstacles to a practical and certain use of the instrument. Huygens had the merit of surmounting all these difficulties, by employing the pendulum in clocks to regulate the motions of a system of wheels, acted on by a constant power which tends continually to make them revolve; the pendulum determining the rate of their gradual rotation, by acting on them at equidistant intervals. The pendulum carries at its upper extremity a piece in the form of an anchor, which is termed the escapement, and of which the two ends, carried successively from right to left, and from left to right, by the oscillatory motion, are alternately engaged and disengaged with the teeth of a principal wheel, whose rotation they thus serve to check, and which, in its turn, serves as a similar alternate check to the other wheels. These now turn more or less slowly, according to the relation of the number of their teeth to that of the principal wheel. By applying, then, to their axes one or more indices, which turn on a dial-plate divided on the outside, we obtain by their indications so many unities of different kinds, the amount of which shows the number of oscillations that have been made. These unities of time are *hours, minutes,* and *seconds.* Great care is taken in the construction, as well as in the application of the wheels, so that their motion may be as easy as possible, and that they may always obey, with equal facility, to the intermitting impressions of the pendulum. The body of the pendulum itself is constructed with particular precautions. It is formed of a rod, or system of rods of metal, terminated below by a mass also of metal, and very heavy; generally of a lenticular form, which, as the edge lies in the direction of the plane of oscillation, possesses the advantage of diminishing the effect of the air's resistance. Besides this, as the dilations and contractions of the metal, by the changes of temperature, would lengthen or contract the pendulum, and thus cause it to alter the duration of its oscillations, the stalk of the pendulum is composed of a number of slips of different metals, which are so combined, that the centre of oscillation of these slips, and of the lenticular weight, remains constantly at the same height.

Such is, in general, the mode of applying the pendulum to clocks, which we owe to Huygens, and which, by the exactness it has introduced in the measurement of time, is one of the finest and most valuable presents which the sciences have ever received from the hands of genius.

The second application of the pendulum, namely, its use in determining the resistance of fluid media, we owe to Newton, who has explained it with much detail in the sixth section of the first book of the *Principia.* The intensity, and the law of the resistance, is estimated from the progressive diminution of the amplitudes, determined by observation. We may see in that part of the work above referred to, the profound nature of the theory on which this deduction is founded, as well as the experiments themselves to which Newton applies it. The pendulums which Newton made use of were, in general, spheres of wood, or of metal suspended by threads. Besides the law, also, of resistances, several important points in physics depend on this sort of observation. Newton, for example, made use of it to establish the fact, that the action of terrestrial gravity upon all bodies is proportional to their mass; and also to inquire if these bodies, when in motion, suffer any sensible resistance by the presence within them of subtle media, which have been supposed to spread throughout the whole universe.

Lastly, it now remains to consider the use of the pendulum in measuring the intensity of gravity on different parts of the terrestrial spheroid; and we have kept this application for the last, on account of the delicate nature of the experiments which it requires, and which are now really performed. It would be of no use to enumerate here all the methods which have been successively employed, and successively abandoned, as experiments of greater exactness came to be required. Even the results of these first attempts, though they may have been at the time very useful, cannot now be any more employed; so much do the limits of the errors which they admitted of exceed those which are allowed by our actual processes. These can be reduced to three principal methods; two of them give the absolute measure of the pendulum; the one is due to Borda, the other to Captain H. Kater; the third gives merely the relations of the lengths of pendulums in different places, and deduces these, by comparing the number

of oscillations performed in the same interval of time by the same compound pendulum, supposed to be of an invariable form, and which is carried successively to the different places of observation.

I.—Borda's Method.

The method used by Borda was originally described in a memoir, inserted in the third volume of the work which Delambre has published, under the name of *Base du Systeme Metrique Decimal.* The same memoir includes a detailed account of a very great number of experiments performed in this manner by Messrs Borda and Cassini, to determine the length of the seconds' pendulum at the Observatory at Paris. The method of Borda has been since simplified by the French astronomers, so that, without losing any of its original exactness, it has been rendered more easy of execution in travelling, and in places where the observer can only reckon upon the resources he carries with him. Under this new form, this method has been employed on a great number of points of the terrestrial arc, comprehended between the Pithiuse Islands and the Shetland Islands. The description of these modifications, and of the results thus obtained, will be found in a volume which forms a sequel to that of Delambre, and which has been published by Biot and Arago. It is from thence that we shall take our general account of this method, the description of which will serve also for the explanation of the others; these having many points in common with it.

The fundamental principle of this method consists in employing for a pendulum, a system of bodies which approaches the nearest possible in its properties to the simple pendulum, and which we can reduce to this ideal case by corrections equally simple to calculate, and exact in their application. The pendulum is formed by a ball of platina, suspended to a metal wire. (Plate CIX. fig. 3.) The under extremity of the wire is screwed into the bottom of a spherical cap of copper, of the same radius as the ball, and which being applied on its surface with a little tallow, adheres to it in consequence of the pressure of the atmosphere, and of the perfect contact resulting from its sphericity. The other end of the wire is attached to a suspended knife (fig. 4), which oscillates on a plane of agate (fig. 5), furnished with adjusting screws, by which it can be brought perfectly horizontal; a circumstance which is ascertained by placing on this plane a glass spirit level without its frame. The mass of the knife is previously adjusted, so that its oscillations may be very nearly isochronous with those of the clock, by which the whole pendulum must be regulated. This is done by the motion of a small ring of metal A, which screws round a metal rod T T fixed to the knife, and which, by screwing and unscrewing, approaches to, or recedes from, the plane of suspension, giving to the momentum of inertia of its mass a greater or less influence on the motion of the system of the knife and its rod. When the isochronism of the oscillations of the knife and of the clock is as perfect as can be obtained by this method, we suspend from the knife the wire and ball; giving to the wire such a length, that the oscillations of the whole system may differ but little from those of the clock, consequently from those of the knife itself. It can then be shown, as well by calculation as by experiment, that the mass of the knife exerts no sensible influence on the length of the pendulum; which arises from its centre of gravity being then excessively near the plane of suspension. The whole system of the knife, the ball, and the wire, has only now to exert an effort infinitely small, to complete the exact regulation of the oscillations of the knife, and to make them agree with those of the whole system.

The pendulum is inclosed with the clock in a glass case, where it is exempt from the agitation of the air. Behind the wire, at a very small distance, is fixed horizontally a scale of equal parts, which serves to measure the amplitudes of the oscillations. Two sensible thermometers, carefully adjusted, are fixed near the wire, the one at the height of the plane of suspension, the other at the height of the ball, in order to indicate, at every instant, the temperature of the air around the wire. But as the wire, on account of the smallness of its mass, receives the impressions of temperature much more rapidly than the most sensible thermometer, the experiment is made in a room so large and sheltered, that the temperature of the air in it may change very slowly. The state of the thermometers is observed through the glasses of the case without ever opening it during the period of the oscillations.

Every thing being thus disposed, we place, at the distance of seven or eight metres, a telescope fixed horizontally, and the eye-glass of which has a wire fixed vertically before it. We direct this wire upon that of the pendulum, when in a state of rest, and we then place in the same direction, on the ball of the clock, also at rest, a small circle of paper to serve for an index. These preparations being made, the clock is set to oscillate, and is no more stopped. When its rate of going has become very steady, we cause the pendulum also to oscillate, and shutting the door of the glass case, we proceed to observe it from without with the telescope. If it should move exactly at the same rate with the clock, it would always be found in the same position in relation to the index in all its consecutive oscillations. But this never happens, and the pendulum goes always quicker or slower than the clock. If it goes quicker, it only coincides for an instant with the index, after which it passes it, recedes from it, returns to it in the opposite direction, passes it anew, and, after having receded from it again, returns to coincide with it a second time, and follows its motion of oscillation for an instant. The telescope which serves to observe these separations and these coincidences, magnifies the arc described by the pendulum, and by the clock—augments their apparent velocity, and thus enables us to judge of the instants of coincidence with singular precision. Between two consecutive coincidences, the pendulum gains or loses two oscillations upon the clock, and a simple proportion determines how much it must gain or lose in 24 hours of the clock, if it be sexagesimal, or in ten hours if it be decimal. If we suppose N to denote the interval between two coincidences, in clock time, it follows, that while the clock makes N oscillations,

the pendulum makes $N \pm 2$. The sign $+$ being employed, if the pendulum goes quicker than the clock, and the sign — if it goes slower. Thus, during any number of oscillations of the clock, denoted by J, the number of oscillations of the pendulum will be proportionally $J\left\{\frac{N \pm 2}{N}\right\}$ or $J \pm \frac{2J}{N}$, a result which we may represent in an abridged form by $J \pm n$.

If the clock be sexagesimal, the number J of its beats in 24 hours is 86,400. If it be decimal, this number is equal to 100,000. Both these systems have been employed by the French observers. Whatever may be the one which we adopt, we regulate the length of the wire of suspension in such a manner that the coincidences of the pendulum with the clock may not be very near to each other, which would multiply unnecessarily the trouble of the observer. But neither must they be made too distant, because, in that case, the pendulum and the clock detaching themselves too slowly from each other, the precise instants of each coincidence become more difficult to observe. A few trials will soon point out a convenient medium between these extremes. Then the difference in the diurnal rate $\pm \frac{2J}{N}$, or n between the pendulum and the clock always forms a very small number of oscillations. But the extent of the arcs described by the pendulum, diminishing always by the effect of the resistance of the air, while the clock, having its motion restored by the action of its weight, preserves always the same amplitude, it hence always happens that the intervals between the successive coincidences of the same pendulum vary with the time, which alters the value of the number n. During this inevitable change, the period when the coincidences are observed with the greatest precision is that where the amplitudes of the oscillations of the pendulum and of the clock are equal to each other; so that, if we are obliged, by any consideration, only to observe a small number of coincidences, we must regulate the primitive range of the pendulum, so as to approach as near as possible this condition of equality.

The difference in the rate $\frac{2J}{N}$ or n corresponds with those oscillations of the pendulum, which are performed between the coincidences which we compare together, that is to say, with an amplitude of arc varying from 2α at the beginning of the interval to $2\alpha'$ at the end of it. The duration of these oscillations is larger than if the oscillations had been performed with the same pendulum, but with amplitudes infinitely small; and, therefore, to render the results comparable with each other, they must be reduced to this latter case. For this purpose, at the moment of each coincidence, we observe, through the fixed telescope, the point of the horizontal scale at which the wire stops in its excursions on each side of the vertical. This furnishes sufficient data to calculate the angular deviation of the pendulum from the vertical, at the instant of the coincidence, since we know the distance of the scale from the plane of suspension at which the centre of rotation lies. We mark also the state of the interior thermometers, and that of the barometer at the same instant. If the arcs α and α' are both very small, as it is usual to make them, we may, without sensible error, suppose all the oscillations made with the mean amplitude $\alpha+\alpha'$. Then, after what has been shown above, each of them expressed in oscillations infinitely small, will be equal to $1+\frac{1}{16}\sin^2(\alpha+\alpha')$, which we may express in an abridged form by $1+\mu$, and consequently the $J+n$ oscillations of the pendulum supposed to be made in this arc, will be equal to a number of oscillations infinitely small, expressed by

$$(J+n)(1+\mu) \text{ or } J+n+\mu(J+n)$$

a result which we may represent in an abridged form by $J+n'$. The number n', according to what has been above established, never being any way considerable.

If the arcs 2α, $2\alpha'$ differ more than in a slight degree from each other, as, for example, when the interval between the coincidences which we compare is large enough for permitting the resistance of the air to have a considerable effect in modifying the first of these arcs, it will then be no more sufficiently exact to suppose all the oscillations made with the mean amplitude $\alpha+\alpha'$. But this inconvenience may be remedied, by observing experimentally the law of the gradual decrease of the amplitudes. This law is in geometrical progression when the number of oscillations increases in arithmetical progression, that is, if we begin with the instant when the half-amplitude was α, and represent by α_n the amplitude, which takes place after n oscillations, we find $\alpha_n = \frac{\alpha}{K^n}$ or because α and α are supposed very small sin. $\alpha_n = \frac{\sin \alpha}{K^n}$. K being a coefficient, which, in the same state of the air, is constant for the same pendulum, and depends on its length, its shape, and its other physical qualities. This law, first remarked by Borda, and since confirmed by the other French observers, is a necessary consequence of the smallness of the amplitudes, and of the feebleness of the resistance, which alters each amplitude in succession, proportionally to its extent. But however this may be, it is enough that it really subsists, to enable us to calculate by it the exact sum of the squares of the half-amplitudes in the successive oscillations, a problem which is reduced to the summing of a geometrical progression of n terms, of which the ratio is $\frac{1}{K}$. This sum is simplified when we consider the extreme minuteness of the arcs which we compare, and by then pushing the approximation to their second power inclusively, which is the limit of the correction necessary for each individual amplitude. We thus find

$$\mu = \frac{\sin(\alpha + \alpha') \sin(\alpha - \alpha')}{32\,M\left\{\log \sin \alpha - \log \sin \alpha'\right\}}$$

M being the modulus of the tables of common logarithms, or 2.30258509. If we suppose the arcs α and α' so small, that in the developement of their series and of their logarithms, we may limit ourselves to their first power, this expression of μ becomes what we have already obtained by our first approximation.

By these calculations we ascertain the rate of the relative going of the pendulum on the clock, which serves to measure the intervals between the coincidences. We know that it performs $J+n'$ infinitely small oscillations, while the clock makes J of them. Suppose now that the latter *advances* during the mean solar day, a number of oscillations equal to h, that is, that it performs $J+h$ oscillations during the same time that a clock, exactly regulated by mean time, performs the exact number J, we shall evidently obtain this proportion; J oscillations of the clock are to $J+n'$ infinitely small oscillations of the pendulum, as $J+h$ oscillations of the clock, or a mean solar day are to the number of oscillations of the pendulum during a mean solar day. The latter number is thus found equal to $\frac{(J+n')(J+h)}{J}$ or $J+n'+h+\frac{hn'}{J}$, the quantity which, for simplicity, we shall represent by $J+n''$. With the apparatus so disposed as we have described, if the clock is not very far from mean time, so that h denotes a small number of oscillations, the correction expressed by the last term, the only one which demands a calculation, will be of an extreme minuteness, and easily obtained with great precision.

It now remains to measure the length of the pendulum from the plane of suspension to the bottom of the ball of platina. For this purpose we place beforehand, under this ball, a small plate of metal, well polished, perfectly horizontal, and which can be made to sink or rise vertically by means of a screw, of which the threads being very fine, permit the smallest motion. (See Plate CIX. fig. 6.) When the coincidences are finished, we open the glass case, and we raise gently this plane until it comes in contact with the ball of platinum. We must be equally careful to avoid raising it too much, which would raise the ball, and make the pendulum too short, or not raising it so high as the contact, which would give a pendulum too long; but if we take for an index the disappearance of a thread of light between the plane and the ball, at their common point of contact, we may then succeed, by a little skill, in fixing this contact with the utmost degree of rigour. This, however, is never done at the first attempt, for the entry of the observer into the glass case, however short, always elevates in a slight degree the temperature of the air contained in it, and consequently that of the wire, which acquires this temperature in the same instant, from whence arises a small increase of its length, which we ought to be aware of. On this account, instead of establishing a perfect contact between the plane and the ball, in that accidental state of the wire which the interior thermometers, less sensible than it, do not perhaps indicate with sufficient exactness, it is better to confine ourselves at first to the mere preparing for the operation, by making the little plane approach extremely near the ball, without, at this time, actually touching it. We observe now the point where the index of the screw that moves the ball stops, and then coming out of the glass case, we shut it until the temperature within, and the thermometers which measure it, have had time to return to a state of rest. We then open the case anew, and finish in an instant the operation of contact, which is easily done, as we have only to give to the plane of contact a very slight degree of motion, and such as we are previously quite prepared for. At this moment, or rather before entering the glass case, we mark the temperature of the thermometers within, and consider this as the temperature of the wire at the instant of contact.

The distance of the plane of suspension from the bottom of the ball is now fixed, and in such a manner, that it is henceforth invariable, or at least we may suppose it such during a long interval of time. For, the supports of the plane of suspension being fixed in the wall itself, and those of the plane of contact being cemented to a large stone resting on this wall, or sunk into the ground, the accidental variations of temperature cannot alter the distance which separates them, excepting in a very slow degree.* It remains then to measure this interval by means of a divided rod of metal; but to determine the length of such a rule, its extremities must be quite free; and how can we, in that case, apply its summit exactly on a level with the plane of suspension? Borda has very happily resolved this difficulty, by adapting to one of the extremities of the rule a knife of suspension, which is fixed to it, so as to touch it on its edge. (See fig. 7.) Suppose we wish first to measure the length of the rule, we take off the knife, and apply the rule itself to the apparatus intended for that object. If we wish then to measure the length of the pendulum, we replace the knife, and suspend the rule, thus armed, on the plane of suspension, in place of the pendulum itself. In our experiments, the knife is adapted to the rule by means of a metal case; the rule is inserted into this case until it touches the knife, when it is fixed

* Considering the indispensable necessity which there is of preserving rigorously this quantity invariable, it appears to be of extreme importance, that the ground may not yield when the observer approaches to complete the measurement. The only means of avoiding, beyond suspicion, this possibility, is to construct round the pendulum a platform, supported on certain points of the ground, at a distance from the stone which carries the little plane with which we effect the contacts of the ball, so that this apparatus may become quite independent of the motions of the observer.

in this position by means of a strong pinching screw, denoted by V, and which is screwed by an iron key. It only remains to alter the length of this rule in such a manner as to render it exactly equal to the actual distance which is found between the bottom of the ball and the plane of suspension. For this purpose, in the experiments of Borda, the rule carried, on its under part, a divided tongue, having a free motion. When the observations of the coincidences were finished, the pendulum was removed, and for it was substituted this rule, of which the tongue was let down until it fell upon the little plane which had touched the ball of the pendulum. Then by reading, with a magnifying glass, the divisions of the tongue, it is easy to know the distance between the bottom of the ball and the axis of suspension.

In Borda's experiments, the pendulum was twelve feet long. A rule of such a length could not have been carried in travelling, or even in stations of difficult access, without the risk of serious errors, resulting from the bending which it must have received. On this account the French observers, who were entrusted with such experiments, thought it necessary to modify in this point the apparatus of Borda, and they confined themselves to pendulums much shorter; as are those which swing mean sexagesimal or mean decimal seconds. This enabled them to make use of rules much shorter, more portable, and which they could also make larger and more solid without increasing too much their weight; but then it became indispensable to introduce a still greater degree of precision than before into the determination of the length of the rules; into that of the divisions traced upon the tongues which were fixed to them; and, lastly, into the measurement of the variable parts of these tongues, which were used in each experiment, in order to adapt them to the different lengths of the pendulum which they were intended to measure. All these elements were obtained with unexpected exactness, by employing for their determination the apparatus already used with such success for the comparison of metrieal scales, under the name of *comparateur*. All the details of this application may be seen in the work of Biot and Arago, above referred to.

By means of the operations above described, we find the total length of the pendulum from the plane of suspension to the bottom of the ball of platina; such at least as it is at the instant of contact of the latter with the little plane. But this length may not be, and is not in general, the same which the pendulum has when it began to oscillate; because the temperature which modifies almost instantaneously the length of the wire cannot have been the same at the time of the contact of the plane, and during the observation of the coincidences. But it is to this state that we must evidently reduce the length that we have attained. For this purpose, let it be denoted by Λ, and suppose t' the temperature of the wire in degrees of the thermometer at the instant of contact, t being its mean value, during the coincidences; then if R' represent the radius of the ball of platina at the temperature of t' when the contact was produced, the length of the wire at that instant was $\Lambda-2R'$; so that, calling K the lineal dilatation of the matter of the wire, for a difference of one degree in the temperature, the length of the wire at the time of the oscillations must have been $(\Lambda-2R')\left\{1+K(t-t').\right\}$ In the same manner, if K' be the lineal dilatation of the substance of the ball, its diameter, at the time of the oscillations, will be $2R'\left\{1+K'(t-t'),\right\}$ and adding this quantity to the length of the wire, we obtain $\Lambda+\Lambda K(t-t')+2R'(K'-K)(t-t')$ for the distance of the plane of suspension from the bottom of the platina ball during the actual time of the oscillations. By deducting from this length the radius of the ball, such as it was at the same instant, that is, $R'\left\{1+K'(t-t'),\right\}$ we shall have the distance of the centre of the ball from the plane of suspension, a distance which we shall call h. This being determined, if the wire which sustains the ball, and the cap which fits upon its surface, were both without weight, or if their weight could be altogether neglected in comparison with that of the ball, the length l of the simple pendulum isochronous with the compound one thus formed would be obtained by the above formula, and would be $l=h+\frac{c'}{mh}$, m being the mass of the ball, and c' its momentum of inertia relative to an axis drawn through its centre. But calling ϱ the density of the mass of the ball, and R its radius, at the temperature at which the pendulum oscillates, its mass m is equal to $\frac{4}{3}\pi\varrho R^3$, and the value of c' is $\frac{8}{15}\pi\varrho R^5$. Substituting these values, we have $l=h+\frac{2R^2}{5h}$; hence it appears, that it would be easy to calculate l, since R and h are known. But, in truth, the weight of the wire and that of the cap can never be absolutely nothing. They are only very small, relatively to the weight of the ball; so that the preceding value of l is but an approximation, which, to become quite exact, requires a small correction, depending on the relation of these masses. This correction being rather complicated in its expression, we shall not repeat it here, but refer to the memoir of Borda, or the work of Biot and Arago, already mentioned, and represent it by Q; as it is always negative, the length l of the simple pendulum isochronous with the pendulum observed, will become $l'=h+\frac{2R^2}{5h}-Q$. Now we have seen, that, in these experiments, the apparent gravity which impels the pendulum is less than the real gravity which operates in vacuo, on account of the statical effect of the ambient medium; but for a simple pendulum of the length l moved by the force of gravity g, the time T of its infinitely small oscillations is expressed by $\pi\sqrt{\frac{l}{g}}$; and if we wish to obtain oscillations of equal duration with different forces of gravity, we must vary the lengths in proportion

to these forces, so that the relation $\frac{l}{g}$ may remain constant. Now, after what we have before seen, if we denote by D the density of the substance of the pendulum at the temperature of freezing, and under the atmospheric pressure of $0^m.76$, that of the air being 1, if, besides, we denote by c the cubic dilatation of this same substance, the relation of the apparent gravity in air to the gravity in vacuo, under the pressure p, and at the temperature t, will be expressed by $1-\frac{p}{0^m.76\,(1+t.0.00375)\,(1-t)D}$, which, for simplicity, may be represented by $1-\gamma$. Then, to obtain the length l'' of the simple pendulum, which, making its oscillations in vacuo under the influence of the gravity g, would be isochronous with the actual pendulum l', going in the open air, we must take $l''=\frac{l'}{1-\gamma}$, which, on account of the smallness of γ, may be reduced to $l''=l'+\gamma l'$. We have denoted above by $J+n''$ the number of infinitely small oscillations performed by the actual pendulum in a mean solar day. Such, then, is also the rate of the pendulum l''. If we wish, in fine, to obtain the length l''' of a pendulum which would move exactly to mean time in vacuo, under the influence of the same power of gravity as l'', we have only to consider that, according to the preceding expression of T, the lengths l''' must be directly proportional to the squares of the times of their oscillations, and therefore reciprocally, as the squares of the number of oscillations made in equal times. We must take, then,

$$\frac{l'''}{l''}=\frac{(J+n'')^2}{J^2}, \text{ whence we obtain } l'''=l''+\frac{2n''l''}{J}+\frac{n''^2l''}{J^2}.$$

The length l''' thus obtained is now free from all the variable elements, which depend on particular circumstances of their observations. This constitutes what we should properly call the absolute length of the simple pendulum in the place of observation.

The experimental method which we have described, when it is employed with all due care, gives results which, in the same place, are perfectly comparable with each other. For, with various lengths, such as the sexagesimal pendulum, for example, or the decimal pendulum, the deductions from particular experiments do not differ generally from each other more than in the thousandth parts of a millimetre. To establish, however, completely the theoretical certainty of this method, it is necessary to examine more particularly some of the circumstances which form a part of it.

Our first remark relates to the extensibility of the wire to which the platina ball is suspended. It is clear, that, during the period of each oscillation, the wire is impelled in the direction of its length by two forces of different kinds, and of different intensities; of which the one is the varying traction, acting on it every instant by the weight of the ball decomposed into its direction; and the other is the centrifugal force, which the motion of oscillation generates. It may evidently be a question, whether this double action has not on the oscillations a sensible influence, which, disappearing in the measurement of the length taken when the pendulum is at rest, would alter the result which we have obtained. M. Poisson has submitted this question to calculation in the eighth volume of the *Journal de l'Ecole Polytechnique*, and he has found, first, that the symmetry of the oscillations on each side of the vertical is not altered by the extensibility of the wire; at least if we suppose them to be performed in vacuo, a circumstance which it was easy to anticipate from the symmetry itself of the mode of action of this force. But he has found that their duration is affected with a periodical inequality, in consequence of which the successive oscillations are not isochronous among themselves. When the total extension, however, suffered by the wire is very small, which is generally the case in experiments where the wires are formed of metallic substances, the effect of this inequality neutralises itself in the mean duration of a great number of oscillations; only this mean period is a little longer than if the wire had been altogether inextensible. Let l, for example, be the lineal length which the wire would naturally have if left to the sole attractive action of its particles on each other; and suppose that, by suspending the platina ball at its lower extremity, it lengthens by a small quantity λ. This being the case, if the half-amplitude of the oscillation is denoted by α, M. Poisson finds that limiting the results to the square of α, the mean duration T of the whole oscillations will be,

$$T=\pi\sqrt{\frac{l}{g}}\left\{1+\frac{1}{16}\left(1+\frac{11\lambda}{l}\right)\sin^2\alpha\right\}.$$

If we wish to suppose the wire inextensible, we have only to make λ equal to nothing, and it hence appears that the extensibility only modifies the correction of amplitude, already in itself so small, and alters it by a quantity which, from the small extensibility of the metals, cannot in general produce any effect that could be detected by observation.

A second circumstance, which deserves equally to be examined, is the probable influence of the motion of rotation of the platina ball round the direction of the wire, and any twisting which the wire may suffer during the oscillations. M. Poisson has examined, by a calculation in the *Connoissance des Tems* for 1815, the effect of such a motion; and he has found that, in the ordinary disposition of the pendulum of Borda, it is rendered in a manner insensible by this circumstance, that the momentum of inertia of the ball, and of the whole pendulum, relatively to an axis drawn through the direction of the wire, is a very small quantity. Let R be the radius of the platina ball, h the distance of its centre from the axis of suspension, α the angle which the rotation of the ball makes each of the points of its surface describe during the period of an oscillation, this angle being measured in a circle of a radius equal to 1, T the time of an infinitely small oscillation of the same pendulum, in the case when the rotation is nothing;

M. Poisson finds that the real duration of the oscillations will be T $\left\{1-\frac{\alpha^2 R^4}{50h^4\pi^2}\right\}$, π being always as before the relation of the circumference to the diameter, or, what is the same thing, the semi-circumference, of which the radius is 1. In regard to the effect of the torsion communicated to the wire by the rotation of the ball, M. Poisson proves that it can have no influence on the duration of the oscillations. In the shortest lengths of pendulum which have been observed by the above process, R was less than $0^m.02$, and l nearly equal to $0^m.74$. Adopting these numbers, and supposing, besides, that the ball describes two whole circumferences for each oscillation, which would be a very rapid motion of rotation, we shall then have $\frac{R}{h}=\frac{1}{37}$; $\frac{\alpha}{\pi}=4$, and consequently $\frac{\alpha^2R^4}{50h^4\pi^2}=\frac{1}{5856569}$, whence it appears that the time of the oscillation would be diminished only by a quantity altogether insensible, even on the above suppositions. But it is far from being the case that a rotation so rapid as we have supposed really takes place in the experiments; on the contrary, when we set the pendulum in motion, we take great care to avoid every movement of this kind; we also pay particular attention to let fall the ball without any lateral impulse, so that its oscillation may be performed as exactly as possible in a vertical plane, which we also take care to verify by observation, when the pendulum is in motion. It would be useless to attempt to obtain this condition in a manner more exact; for it is known by the calculation of conical oscillations, that when these take place in an orbit much flattened, their duration is almost exactly the same as if they were quite plain.

The last object to be considered, and of which the discussion is as important as it is delicate, is the influence which the form of the suspending knife may have upon the oscillations of the same pendulum. Comparing, indeed, the motion of the pendulum to that which would take place round an axis of suspension perfectly rectilineal and mathematically straight, we suppose, or, at least, seem tacitly to suppose, that the edge of the knife forms such an axis, which is physically impossible, since the most perfect art cannot give it any other form than that of a round surface, the breadth of which is sensible to the microscope, and which even there appears always like a saw indented with teeth more or less deep. Now, if this surface were a circular cylinder, a simple calculation, which was first made by Euler, shows that the durations of the oscillations will be the same as if they were performed round a rectilineal axis placed *under* the surface of the cylinder, and at a distance equal to the radius of its curvature; and in the case of very small oscillations, this result may be extended to a knife of any form, if we take for its curvature that of its osculating circle. Hence it follows, that in order to have the true length of the simple pendulum in this circumstance, we must subtract the radius of this circle from the length calculated on the hypothesis of a rectilineal axis, according to the oscillations observed. But such a correction would throw great uncertainty upon the results; for the osculatory curvature of the knife cannot be measured, or even appreciated by any process, and it must vary considerably, either by the difference of workmanship in different knives, or by the inevitable wearing which the edge of the knife undergoes, when the weight suspended from the wire presses it against the plane of suspension. Fortunately, the extent and the variableness itself of the effects which this cause should produce, serve to prove that it has no action whatever in experiments; for, in the first place, by loading successively the head of the same knife with several weights very different among themselves, in order to observe if these different systems, previously according with the same clock, would have an influence on the length of the pendulum; now Borda has found that this influence was absolutely insensible, although the curvature of the edge, to which he did not pay attention, was then undergoing very different modifications under the unequal compressions to which they were subject. Secondly, The length of the simple pendulum, beating seconds at the Observatory of Paris, which Borda had deduced from a pendulum of 12 feet long, has since been found as exactly the same as the difficulties of the operation would permit, by employing, with the same knife and the same ball, wires four times shorter, which gave a much greater influence to the alterations of length which the curvature of the knife could produce. Lastly, By observing successively, at the same place, with the same ball, and the same length of wire, but with knives whose edges presented an extreme diversity, from the highest possible finish, to the greatest coarseness in the execution, M. Biot has obtained, at Leith Fort in Scotland, such lengths for the simple pendulum, between which no sensible difference could be observed, although no correction whatever was made for the curvature of the knife. These proofs of different kinds, but all agreeing in their consequences, seem to show evidently that in the process of Borda the shape of the edge of the knife has no sensible influence on the results, and that it is unnecessary, therefore, to pay any attention to it; and yet, as the theory of oscillations round cylindrical axes cannot be questioned, we must either conclude that in this circumstance the oscillation is really not performed on a cylinder of sensible dimensions, but upon the ideal axis of insensible dimensions, formed by the asperities which still exist in the grain of metal of which the knife is composed; or that the agreement previously established between the proper motion of the knife and the total motion of the pendulum, compensates physically the effect which the curvature of the knife would have upon the oscillations, if it consisted really of a simple cylinder without mass attached to the wire.

II.—Method of Kater.

The method employed by Captain Kater to measure the length of the pendulum is founded upon this theorem of Huygens, that whatever be the form of the oscillating body, the centre of oscillation

and the centre of suspension are reciprocals to each other, a theorem of which we have already given the demonstration. To realise this disposition, Mr Kater chose a body of such a form, that it was easy to determine by calculation the approximate position of its centre of oscillation for a given position of the axis of suspension. These two points being thus known, he fixes there immoveably two knives parallel to each other. In the space which separates them he then adapts to the body a moveable weight, and having first placed it at random, he makes the system oscillate successively upon the one knife and upon the other. If, as it almost always happens in the first trial, the oscillations performed in the two cases are of unequal duration, he moves the intermediate weight, so as to bring them nearer to an equality; then, comparing these anew by observation, he finds necessarily a less disparity between them, which he again reduces, until at last, after a few trials, the duration of the oscillations performed round the two axes become exactly equal. The justness, as well as the rapidity of these reductions, are favoured by the form which Mr Kater has chosen for his oscillating body. This form is a simple rectilineal bar of copper, towards the two extremities of which are placed two known weights; the one of which is immoveably fixed, and the other being moveable, but, at the same time, capable of being fixed in a similar manner, serves first, by its motion, to establish between the two knives, not exactly, but approximately, that reciprocity between the oscillations to which it is desired to bring up the system. This reciprocity is then rendered rigorously exact, by the much more delicate motion of a third smaller weight placed between the knives, in that part of the rod, where we know, by calculation, the effect of its displacement will have the least sensible influence upon the oscillations, which is found to be towards the middle of the rod, in the division of the weights adopted by Mr Kater. A divided scale, engraved upon the bar of the pendulum itself, serves to measure the displacement of this latter moveable weight. In the experiments of Mr Kater, this scale was divided into 12ths of an inch, and a displacement of 12 parts produced a difference of about four seconds in the diurnal rate of the system, reckoning sexagesimally; whence we may be able to appreciate the extreme delicateness of this mode of regulation. The bar, with its weights, is represented fig. 8, Plate CIX. Fig. 9 shows its disposition during the observations.

It is then, as appears, placed before a clock, with which it is compared, by means of a fixed telescope, after the method of coincidences of Borda. But the mode of experiment employed by Kater, requiring the oscillations round the two axes to be observed in a state of rigorous equality, it becomes necessary to avoid, in their comparison, every change of temperature, and thus it is necessary to make the results independent of the variations of this kind, which inevitably arise in the atmosphere. That could only be obtained by rendering the series of coincidences very short, and multiplying the successive inversions of the apparatus. But then, to obtain the same exactness, it is necessary to fix the coincidences with much greater precision than in the method of Borda, where the little influence which they have is one of the principal advantages. Mr Kater has attained this object, by fixing upon the lentil of his clock a white disc, traced upon a black ground, and of such a size, that it is exactly covered, and no more, by the interposition of the bar of the pendulum, when this is at rest in the situation of the vertical. This same occultation, being then observed during the motion of the clock and of the pendulum, serves to fix the instant of the coincidence; and Mr Kater finds, that in this manner there cannot be any error greater than a second on the instant to which each coincidence belongs.

The rest of the details of the observation are the same as in Borda's process. The amplitude of the arc of oscillation is observed at each coincidence, as well as the state of the barometer and thermometer; and these are employed in the same manner, to reduce the oscillations to what they would have been, if they had taken place in vacuo, and with amplitudes infinitely small, at the observed mean temperature of the oscillating body.

It still remains to obtain the length of the simple pendulum corresponding to this rate of going. After an equality has been obtained in the oscillations round the two knives, this length is equal to the distance between the edges of the knives, at the moment of the oscillation of the pendulum, at least if we consider these edges as lineal axes. It would be evidently impossible to observe the distance in question during the actual motion of the pendulum; but this defect may be supplied by determining it first for some known temperature, and reducing it by calculation to the value which it ought to have during the coincidences, according to the temperature at the time these took place, and the dilatation of the substance of the pendulum, which is also known. It is thus that Mr Kater operated, and he has obtained the true distance between the knives, in comparing it by a microscopic process, with the metal rule which he employed as a standard of measure. In order that this operation may be put in practice, the two edges of the knives must be very exactly parallel. Mr Kater accordingly disposed them in this manner before the experiments, employing the measure itself of their distance to determine and to prove the accuracy of their position, to which they were gradually brought by means of adjusting screws, which allowed each knife to move by very small displacements. He also took advantage of this method, to render their direction quite perpendicular to the length of the bar. Lastly, as the distance between the knives, which we are seeking to determine, is that which took place when the pendulum was in a vertical situation, Mr Kater, during the measurement, applied to the bar, now horizontal, a force of longitudinal traction equal to what it exerted on itself by its own weight, and in a state of oscillation. In calculating the influence which the curvature of the knives, supposing it to be circular, can have upon the length of the simple pendulum, deduced from the oscillations of a similar apparatus, M. La Place has found it to be equal to nothing, and that this length was always rigorously equal to the distance between the edges of the knives. This theorem is only true, on the sup-

position that the two edges are of the same curvature; but whatever precaution may be taken to render them identical, even making them together, and with a single piece of steel, it will be impossible to be assured, that there may not be found differences, not merely very small, but very considerable in the radii of curvature of their osculatory circles; since these circles are the result, not of any measured and geometrical operation, but of a work of reducing and polishing necessarily vague and irregular. It would appear then by this, that the results of this method would still be subject to the same uncertainty in theory as the results of the others are; but these uncertainties are dispelled in both cases, by the experimental proofs already described, that, in the process of Borda, the figure of the edge of the knives has no influence upon the length of the simple pendulum, deduced from their oscillations. In short, what completes the proof, that these two methods do not include in themselves any source of inaccuracy, is the surprising and almost ideal coincidence of the results which they afford, notwithstanding the diversity of the two processes. We shall have occasion to give a striking proof of it at the conclusion of the ensuing paragraph.

III.—Pendulums of Comparison.

The two methods which we have been explaining make known the *absolute* lengths of the simple pendulum in every place where it is observed. Both of them, therefore, require to be absolutely determined, on the spot, in lineal measures, and this cannot be done with sufficient exactness but by a process of extreme delicacy, the practice of which implies numerous preparations. But when we wish merely to determine the ratios of the lengths of the simple pendulum to each other, for different places on the earth, we may obtain this without any absolute measurement; and by the mere comparison of the oscillations made in these places in equal times by a compound pendulum of any form. To demonstrate this, suppose, first, that the figure of the mass of this pendulum is quite invariable, and that it suffers neither dilatation nor contraction, by the changes of temperature; or, what comes to the same thing, suppose the observations are always made during temperatures exactly equal; in this case, according to the formulæ laid down in the beginning of this article, the length l of the simple pendulum isochronous with that compound pendulum, may be expressed by $\frac{C}{mh}$, m being the mass of the oscillating body, h the distance of its centre of gravity from the axis of suspension, and, lastly, C its momentum of inertia, that is to say, the sum of all the elements of its mass, multiplied by the squares of their respective distances from the axis of suspension. This length l, then, will be the same in whatever place we observe it, since its analytical expression depends only on the figure of the oscillating body, and the density of its parts; but in no respect on the intensity of the gravitating force which impels it; so that, if we take any compound pendulum of any form whatever, but having its mass and figure constantly the same, and make it oscillate successively in different parts of the earth, it is the same thing as to cause a simple pendulum oscillate successively in the same places. But, supposing the oscillations performed in vacuo, and with infinitely small amplitudes, or, what is the same thing, supposing them reduced to these conditions by calculation, the durations, T′ T″, of the oscillations of the same simple pendulum, whose length is l, are connected with the intensities, g' g'', of the gravitating force, which impels them by the following relations, $T'^2 = \pi^2 \frac{l}{g'}$; $T''^2 = \pi^2 \frac{l}{g''}$; whence we obtain, $\frac{g''}{g'} = \frac{T'^2}{T''^2}$, that is to say, that the intensities of the gravitating forces are reciprocally as the squares of the times of the oscillations; or, what is the same thing, they are directly proportional to the squares of the numbers of oscillations made in equal times. For let N′, N″, be these numbers, and T the total time which corresponds with them, then T′ will be equal to $\frac{T}{N'}$ and T″ equal to $\frac{T}{N''}$; so that, by substituting their values, the preceding relation will become $\frac{g''}{g'} = \frac{N''^2}{N'^2}$. By such experiments, then, made with the same compound pendulum, we may be able to determine the relative forces of gravity in the different places of observation. But we may, with equal facility, deduce from them the ratios of the absolute lengths which it would be necessary to give to two simple pendulums in the same places, for making them bear an equal number of oscillations in a given time; for example, to beat the mean second. For let λ′, λ″, be these unknown lengths, since the corresponding times of oscillation are each one second, we shall have by our general formulæ $1''^2 = \frac{\pi^2\lambda'}{g'}$; $1''^2 = \frac{\pi^2\lambda''}{g''}$, whence we obtain $\frac{\lambda''}{\lambda'} = \frac{g''}{g'}$, that is, that the lengths required are proportional to the intensities of gravity in the two places. But we have seen, that the ratio of the gravitating forces may be deduced from the observations made with the same compound pendulum; and introducing this determination into the preceding expression, we obtain $\frac{\lambda''}{\lambda'} = \frac{N''^2}{N'^2}$. Hence, when we have observed the numbers of infinitely small oscillations made in two different parts of the earth, by the same compound pendulum, of a constant form, the ratio of the squares of these numbers will be equal to the ratio of the lengths of the simple pendulums, which swing seconds in the same places. All these results suppose, as we have seen, that the mass and form of the compound pendulum are rigorously the same at the two stations. To obtain a degree of permanency in the mass, we form the pendulum of metal, cast in one piece, to which we adapt for suspension a knife edge made by a process which ensures the firmness of the connection, and we take

every precaution possible to prevent any physical or chemical alteration from modifying it during the carriage. But the permanency in its dimensions and figure is much more difficult to be obtained, because the inequalities of temperature in the different places of observation, and the accidental variations of natural heat, even in the same place, tend perpetually to disturb it. It is physically impossible to prevent the effects of these alterations in any other way, than by preserving constantly round the pendulum the same artificial temperature; a method which has been really employed, but which requires very great precautions to render the temperature round the pendulum uniform, and a constant attention to manage the sources of cold and of heat in order to maintain it at the same fixed degree. It is on this account more simple, and perhaps more accurate, when the thing is possible, to dispose the experiment so as to have only very slow changes of temperature; then to allow the pendulum to partake of these changes, and to correct this effect on its form by calculation, from the observation of the temperature, and the knowledge of the proper dilatation of the substance of which it is composed. This correction is extremely easy; for if we resume the expression $l=\frac{C}{mh}$, which expresses the corresponding length of the simple pendulum, the momentum of inertia C is of the same order as the mass, multiplied by the square of the dimensions of the oscillating body, and the denominator mh is the product of this same mass by a single dimension; whence it is easy to conclude, that if the dimensions should vary in the same proportion in every direction, which really happens in changes of temperature, the quantity $\frac{C}{mh}$ will vary according to this simple proportion. Hence, if we name l the length of the simple pendulum, isochronous with the compound pendulum, when the latter is at the standard temperature t, and denote by l' the analogous length when the temperature is t', representing also by K the lineal dilatation of the mass of the pendulum, for a change of one degree of the temperature, and for a length equal to unity, we shall evidently have $l'=l\left\{1+K(t'-t)\right\}$. Suppose now the pendulum l' has made a number N′ of oscillations, in a given interval of time, for example, a mean solar day, it will be easy to calculate how many the standard pendulum l would have made in the same time, if it had been acted on by the same force of gravity; for the squares of the numbers of oscillations made in equal times being reciprocally as the length of the pendulums which perform them, the square of the number sought will then be

$$\frac{N'^2 l'}{l}, \text{ or } N'^2\left\{1+K(t'-t)\right\}.$$

Hence we obtain for this number itself $N'\sqrt{1+K(t'-t)}$; or reducing the radical into a series, and limiting it to the first power of K; $N'+\frac{1}{2}N'K(t'-t)$. This approximation is always sufficient, because the coefficient K of the lineal dilatation is always very small in solid bodies, and the difference $t'-t$ of the natural temperatures in the places of observation can never exceed a small number of degrees. Captain Kater, for example, has operated with a similar pendulum, made of brass, the observed lineal dilatation of which was 0.00000982 for one degree of Fahrenheit. In an experiment made in London, this pendulum was found to perform a number of oscillations equal to 86051.32, the temperature being 71°.6. If we wish to reduce this experiment to the standard temperature of 62 degrees, which was adopted by Mr Kater, we shall have $N'=86051.32$; $K=0.00000982$; $t'-t=+9°.6$, whence we obtain, for the correction of the temperature, $\frac{1}{2}N'K(t'-t)=+4''.04$, that is to say, four oscillations, and four hundred parts, added to the number of oscillations observed. By operating in the same manner in every other case, we can reduce all the observations to the constant temperature once fixed as a standard.

But one of the indispensable elements in this reduction is the actual temperature of the pendulum during the experiments, and some precautions are necessary to obtain it with exactness. For the pendulum being always very large compared with the thermometers, which we can place by the side of it, it partakes much more slowly than them of the variations of temperature, so that it ought always to be a little colder than the thermometers when the temperature of the air is rising, and a little warmer when it descends. It would be impossible to estimate these differences of state; but we can render their effect insensible, by operating in a room, so large and sheltered from the sun, that the temperature remains in it nearly constant, or at least suffers such slow variations, that the mass of the pendulum has time to partake of them. For in that case the thermometers will point out the state of this mass in indicating that of the ambient air; or if there remains some difference between both, the effect of this will disappear by compensation in a series of experiments sufficiently repeated.

We have mentioned above, that the corrections relative to the amplitude of the arcs and the density of the air, are made in every place for the compound pendulums, the same as in the experiments with the absolute pendulum. The duration of the oscillations may also be determined in the same manner by the method of coincidences, comparing the experimental pendulum with a clock that is actually regulated by astronomical observations. Thus in applying this process, and these corrections, we shall obtain the numbers of oscillations which a compound pendulum would have made at the different stations, if it had oscillated in vacuo, and at a temperature always constant. Whence we may then deduce the relation of the intensity of gravity at these stations, or the ratio of the lengths of the simple pendulum, swinging the same fixed number of seconds in a given time.

To give an example of this deduction, we shall relate the following result, obtained in 1818, by Captain Kater, with the same compound pendulum the dilatation of which is stated above. The numbers of

oscillations expressed in the last column are reduced by calculation to the case of amplitudes infinitely small, the pendulum in vacuo, and the temperature being the standard of 62° Fahrenheit.

Names of the Places.	Latitudes of the Stations.	Number of Oscillations of the Compound Pendulum in 24 mean Solar Hours.
London, .	51° 31′ 8″	86061″ .30
Leith Fort,	55 58 37	86079 .22
Unst, . .	60 45 25	86096 .84

From other experiments previously made by means of the method of inversion, Captain Kater had determined the length of the absolute second pendulum at London, precisely at the same place, and in the same room, where he since made his compound pendulum oscillate. This length expressed in English inches, on Sir George Shuckburgh's scale, was found to be 39.13908 inches. If then we call this length λ, and λ', λ'' the analogous lengths for the two other stations of Leith and of Unst; also N, N', N'' the number of oscillations of the portable pendulum in these three stations, we shall have, according to the formulæ above laid down, $\lambda' = \lambda . \frac{N'^2}{N^2}$; $\lambda'' = \lambda . \frac{N''^2}{N^2}$, which will give for the length of the simple pendulum, at the station of Leith, 39.15538 inches, at the station of Unst 39.17141 inches. Now, by comparing, by methods of extreme precision, the scale of Sir George Shuckburgh, with a metre of platina, executed under the directions of the Board of Longitude of France, and verified by a commission of several members of this body, Mr Kater has found that the metre, taken at its own standard temperature, which is that of melting ice, is equal to 39.37079 inches of the scale of Sir George Shuckburgh, taken also at its own standard temperature, which is 62 degrees Fahrenheit. Hence, it follows, that any length l expressed in inehes of this scale, taken at its standard temperature, is equal in millimetres to $\frac{1000.l}{39.37079}$. The preceding lengths of the simple pendulum, both at Leith and Unst, being already reduced to this standard state, we may apply to them directly this formula, and deduce in millimetres the following values, which are set down, compared with those of Biot, obtained by the method of Borda, from observations made with great care, the preceding year, in the same stations of Leith and Unst, where Captain Kater has since gone.

Names of the Stations.	Lengths of the Simple Pendulum according to Kater.	Lengths of the Simple Pendulum according to Biot.	Differences of Kater's Measurement.
	mm	mm	mm
Leith Fort,	994.528685	994.524453	+0.004232
Unst,	994.935840	994.943083	−0.007243

The differences of the results, it will be seen, are excessively minute, for they consist only in some thousand parts of a millimetre, which is equal to $\frac{39}{1,000,000}$ of an English inch; and they are besides affected with contrary signs at Unst and at Leith. We may reasonably conclude then, that they fall within the limits of that uncertainty to which all physical results are subject; and it may therefore be inferred, that the method of Borda and that of Captain Kater are equally precise, and give both, with exactness, the absolute measure of the pendulum.

In attempting to carry compound pendulums on distant journeys, or when we are obliged to observe them in places where the apparatus cannot be fixed to solid buildings, this must necessarily be modified, so as to be complete in itself. To do this, we may prepare for the pendulum a support of metal, made from a single casting, the feet of which spreading out, can be firmly fixed in the ground, while they allow the pendulum, at the same time, to oscillate at freedom between them. The upper part of this support must consist of a plate having a longitudinal opening in it, to allow the stem and knife of the pendulum to pass through. On this is fixed, with long screws, a polished plate pierced with a similar opening, and which can be set horizontal with a spirit-level before fixing it; and it is on this plane that we place the knife of the pendulum. A divided scale, unconnected with the pendulum, is placed horizontally, immediately under the lower extremity of its stem, which being furnished with a point, indicates, by its excursions upon this scale, the amplitudes of the oscillations. In order, now, to determine the rate of the pendulum's going, it is not always possible to procure the necessary facilities for employing the method of coincidences. In that case, we may substitute for it the comparison of the pendulum with an adjoining clock, or else with a chronometer, counting as Bouguer did, the whole oscillations which the pendulum performs during a given time, and determining the fractions of oscillations, by observing the part of the amplitude with which the point of the stalk corresponds at the commencement and termination of the interval of the time observed. But in making use of this last process, which is indispensable for fixing the extreme terms of each compared interval, we can dispense with the counting of the oscillations one by one; for, it will be sufficient to follow them with a counter, the rate of which is adjusted very nearly to that of the experimental pendulum, and which we take care from time to time to regulate according to it; accelerating or retarding its motion by an impulse given to its lens before it has lost or gained a whole oscillation. This last part of the proceeding has been suggested by M. Arago, and employed by Captain Freycinet in his voyage round the world. Then it only remains to fix, by observation, the position of the stem upon the arc of amplitudes at the periods of comparison with the chronometer or the clock, and from thence to deduce the fractions of oscillations which the counter could not indicate. These fractions may be obtained from the mathematical law which regulates the motion of the pendulum in each oscillation. If we call $2a$ the whole amplitude with which the pendulum oscillates,

and T the total time which it takes to describe it, also ε the arc which it describes, during the time t, in falling from the extremity of this amplitude, the law of the descent, limited to small amplitudes, gives $\varepsilon = 2\alpha \sin^2 \left\{ 90^0 \cdot \frac{t}{T}, \right\}$ so that, by representing the half-amplitude α by 1000 parts, and supposing t successively equal to $\frac{1}{10}$, $\frac{2}{10}$, $\frac{3}{10}$ of T, or of the duration of a whole oscillation, we obtain for ε the following values:

Values of t in 10ths of the whole Oscillation.	Portions of the Half-Amplitude described.
1	48.9
2	191.0
3	412.2
4	691.0
5	1000.0

It would evidently be of no use to push the calculation of these numbers beyond a half-amplitude, since they must be symmetrical on each side of the vertical, when the values of the time t are reckoned, as they always can be, from the extremity of the half-oscillation in which the pendulum actually is. This being understood, the use of the table is easily explained; for the immediate observation gives the demi-amplitude α at the period of the comparison with the chronometer; it gives also, at this instant, the value of the arc ε, according to the division on the scale of amplitudes to which the stem of the pendulum corresponds. Dividing ε by α, the decimal fraction which will hence result being multiplied by the number 1000, may be compared with the numbers contained in the second column of the above table; and the first column will immediately give, either directly or by interpolation, the fraction of time corresponding to this position of the stem, a fraction which must be added to the whole number N of the preceding oscillations, if the pendulum is on its descent towards the vertical, and subtracted from N+1 if the pendulum is on its ascent towards the end of the oscillation.

The experiments on the variation of gravity at different places on the earth were not at first made with a free pendulum such as we have now described, but with a pendulum adapted to a clock. It was in this manner that Richer discovered the existence of this phenomenon in 1672, in a voyage which he made to Cayenne by order of the Academy of Sciences, for the prosecution of various researches in physics and astronomy, among the number of which was the measurement of the pendulum. On his arrival at Cayenne, Richer remarked that his clock, the weights of which had not been altered since his departure, had a diurnal rate of going of 2′ 28″ slower than at Paris; and not only did this observation prove the fact of the diminution of gravity, in going from the pole towards the equator, but if we had known the details, particularly in regard to the relative differences of temperature, we might then probably deduce a more certain and exact measure of this diminution than what can be drawn from the absolute length of the equatorial pendulum, determined by the same Richer at Cayenne, with the imperfect methods which were then in use. We shall not dissemble that this assertion requires some proof; for the mode of observing by clocks appears necessarily subject to great uncertainty; the pendulum's own motion being constrained or modified by the motion of the wheels. But this influence is not, perhaps, in reality so great as one would be led to suppose; in fact, it is not the pendulum, but the weight applied to the clock, which makes the wheels move; the pendulum merely regulates the intermittances in the fall of this weight by its oscillations, which stop it and set it free by turns; and this alternation is performed by means of the escapement which now disengages itself from the teeth, and then lays hold of them again. When it is disengaged, the action of the weight which turns the wheel excites it, and accelerates its fall in its descent. But, in the ascending half-oscillation, which follows, the same action confines the pendulum and retards it; so that these two contrary efforts, which both operate with very slight degrees of friction, appear like the resistance of the air, and every other constant friction to balance their mutual influences on the motion, in each whole oscillation, and merely to limit the amplitude of the arcs in which this oscillation takes place; a limitation which we can easily take into account, by observing the amplitudes, and reducing all the oscillations, by calculation, to the case of their being infinitely small. It would be curious to make experiments on this subject, and it would be easily done; for it would be sufficient to vary the weight applied to a clock, and to see if the variations of amplitude which would result are such that, in paying attention to them, the clock may be brought back to its original rate. Some observations already made indicate the exaetness of this restitution, or at least the very near approach to it.

In the travels in Lapland, for example, undertaken by the French academicians in 1736, an excellent clock by Graham was carried out to be employed for determining the variation of gravity. This celebrated artist had constructed it for this purpose, and had done so with very particular care. In order to render it more steadily comparable with itself, he had adapted to it a pendulum, formed of a simple verge of copper, to the bottom of which was affixed a lenticular mass of a constant weight; and he had provided pieces which raised the rod up during the voyage, and kept its summit free from all contact, so that the knife edge could not be altered by any friction against the plane of suspension, although the rod was always at liberty to follow the dilatations and contractions produced by the changes of temperature. Now, in the account of the labours connected with this operation, which Maupertuis has published under the title of *Figure de la Terre Determinée*, we find, that with the action of the weight, usually applied to this clock, it made, at Paris, 86394″.4, during a revolution of the fixed stars, in describing arcs of 2° 10′ on each side of the vertical, while, with a weight twice as small, it made 4″ more, that is,

86398″.4 in the same interval, describing arcs of 1° 15′. Now, if we apply here the correction relative to the amplitude of the arcs, which is $\frac{1}{16}N\sin^2\alpha$, calling N the number of oscillations, and α the demi-amplitude, we shall then find, that in the first case it is necessary to add 7″ 711 oscillations, and in the second, 2″563, to reduce each of them to the case of amplitudes infinitely small, which gives 86402.1 and 86401.0 for the total number of oscillations infinitely small in the two cases. These quantities only differ by 1.1, and as the observations at this period were not carried to a greater exactness than this difference, it would be of no use to look for a more perfect agreement between them. We have still the example of a similar proof made by Graham himself, upon another clock, which he had constructed to determine the variation of gravity between London and Jamaica; an object for which it was really employed; its rate having been observed for this purpose by Graham in London, and at Jamaica by C. Campbell, a skilful observer, and the friend of Bradley. In the account of this operation, which has been given by Bradley himself, in No. 431 of the *Philosophical Transactions*, it appears that Graham having taken away the weight from this clock, which was 12lb. 10½oz. and having replaced it by another of 6lb. 30°, the amplitudes of the oscillations, which were at first 3° 30′, were reduced to 3°, and the diurnal rate of the clock slackened by 1½″. Now, if we reduce each of these rates to the case of amplitudes infinitely small, in taking successively for α, 1° 45′ and 1° 15′, we find for the reduction in the first case 5″.03, in the second 2″.6, of which the difference is 2″.4, instead of 1″, which Graham had observed; and as this able artist had not had any other end in view than to prove the small alteration in the diurnal motion by a change of weight so considerable, it is possible that he may not have taken the same pains in determining the temperature and other details of the observation, which he would have done if he had been seeking to determine an element of correction with a perfect accuracy. It appears very probable then, by these examples, that in clocks constructed in this manner, the action of the weight, transmitted by the wheels, accelerates the proper motion of the pendulum, during each descending half-oscillation, as much nearly as it retards it in the ascending half-oscillation which follows. So that these opposite modifications seem to compensate each other, at least with a sensible equality, in each complete oscillation. Whence we may conclude with equal probability, that the greater or less facility in the motions, and the various energies of friction produced by the unequal tenacity of the oil, at different periods, and at different temperatures, can have but a very small influence on the proper motion of a pendulum, and which must become quite insensible by employing an oil of tried permanence of constitution; and above all, by producing artificially, at all the stations, the same fixed temperature as was done by the French academicians in 1736, in their journies in Lapland, and also by the intrepid English mariners in 1820, in their memorable voyage to the North Pole. But admitting the constancy of the results obtained at the same place by this mode of observation, which, we repeat, still wants to be completely proved by new experiments, it is clear that no other method could be more convenient. For it would be sufficient in every place to prepare the clock; to set it up, with every precaution in levelling, which can place it in a state and situation similar to itself; then to compare its rate of going with the diurnal motion of the heavens, either with a small transit instrument, or even by means of a simple telescope, firmly fixed to some immoveable mass, and directed towards a star, the diurnal return of which could be observed with fixed wires, stretched in the focus. Messrs Breguet have begun on this subject a series of experiments, but as the processes for determining results of this nature cannot be too severely scrutinized, we sincerely wish that other observers would make similar attempts, and publish the results deducible from them.

Use of the Pendulum in determining the Oblateness of the Earth, and the Intensity of Gravity at different Latitudes.

According to the theory of universal attraction, if we consider the earth and the planets as having been originally masses in a fluid state, endowed with a motion of rotation round themselves, they must have taken the form of a spheroid, flattened at its poles; and the force of gravity, which is observed at their surfaces, would then be the result of two distinct forces, of which the one is the general attraction, exerted upon each point of the surface by all the particles of matter in the spheroid, according to their masses and distances; and the other is the centrifugal force, excited at the same point by the motion of rotation. But the intensity of the attraction, exerted upon different points of the surface by the whole mass, must be in general variable, as well as the centrifugal force. The union of these two causes, then, must produce in the force of gravity inequalities, which observation may discover. But we may easily rid these inequalities of the effect of the centrifugal force; for this can be calculated for each point, when we know the dimensions of the spheroid, its rotation, and the axis round which it turns. The observations thus reduced present results which are only dependant on the attraction of the spheroid upon which they are made; and they may consequently serve to determine its exterior configuration, as well as the laws of density, by which the attractive matter is distributed through its interior. The remarkable discovery of these relations, between the force of gravity at the surface of the heavenly bodies, and their form, as well as their internal constitution, we owe to Newton; and this great man, in following them out, determined even the value of the oblateness which the terrestrial spheroid ought to have, supposing it elliptical and homogeneous, in order to be in equilibrio with its actual velocity of its rotation. He thus found, that denoting by φ the observed ratio of the centrifugal force, to the force of gravity at the equator, the oblateness of the spheroid must be $\frac{5}{4}\varphi$; and as φ, from observation, may be

estimated for the earth at $\frac{1}{289}$, or at 0.00346031, there results the oblateness $\frac{5}{4}\varphi=\frac{1}{231}$, or 0.004325, a quantity much superior to the observed value, 0.00326; which shows that the terrestrial spheroid is not homogeneous. But, as this element of measure had not as yet been determined in the time of Newton, he could not draw this consequence. He confined himself, therefore, to the determination of the variations of gravity in the case of the supposed homogeneity, and he found it, as it is in fact, proportional to the square of the sine of the latitude. But he erred in endeavouring to extend these determinations to the case of any ellipsoid, composed of concentric strata of unequal density. For, finding that the observations of the pendulum gave the actual variation of gravity in proceeding from the equator to the pole, greater than the calculation established for the case of homogeneity, he thought that the oblateness ought to increase at the same time with this variation, although the real measures of degrees have since pointed out the inverse of this result; for they agreed in giving a slighter oblateness than 0.004325, with a more considerable variation of gravity. Clairault, in his admirable work on the figure of the earth, was the first to point out this error which had escaped Newton; and he demonstrated at the same time this remarkable theorem, that, in all the hypotheses, the most probable that can be formed regarding the density of the interior parts of the earth, which must always be supposed most dense towards the centre, there is always such a connection between the fraction which expresses the difference of the axes, and that which expresses the diminution of gravity from the pole to the equator, that, if the one of these two fractions exceeds 0.004325, the second will fall short of it by the same quantity; so that their sum must be always equal to the double of 0.004325, or to 0.00865. In this case, also, the length of the seconds pendulum varies from the equator to the pole, in proportion to the square of the sine of the latitude. Thus, calling λ this length at any latitude L, and A the length at the equator itself, we have in general $\lambda=A+B\sin^2 L$, B being a constant coefficient, to be determined by observation. It must be remarked, however, that this result supposes the lengths of the pendulum, to be observed, at the very surface of the terrestrial spheroid; for, in receding from this surface, although at the same latitude, the intensity of gravity diminishes nearly in proportion to the square of the distance from the centre, and consequently the length of the pendulum must diminish according to the same law. Reciprocally, then, if we have observed this length at any height h above the terrestrial surface, and that we have found for it a value expressed by l; a being the radius of the earth at this latitude; the length reduced to the level of the sea will be $\frac{l(a+h)^2}{a^2}$, or $l+\frac{2hl}{a}+\frac{lh^2}{a^2}$. But this reduction may be simplified, by considering that, on account of the small height to which we can rise above the earth's surface, $\frac{h}{a}$ is always a fraction so excessively small, that the first power of it is sufficient to be used. So that, limiting ourselves to this order of approximation, the reduced length will become $l+\frac{2hl}{a}$. The term $\frac{2hl}{a}$ forms then the correction which the experiments require that they may be reduced to the level of the sea, and thus rendered comparable with each other. Such is, in fact, the mode of reduction generally employed; but we must remark that it is itself subject to uncertainty. For the mountains on which we ascend attract the pendulum by virtue of their own mass; in consequence of which, it becomes necessary to pay attention to this attraction, that the reductions may be made rigorously exact, instead of applying the bare formula, which supposes the observations to have been made in the open atmosphere. But this is an inconvenience which is unavoidable; for it is impossible to calculate exactly the peculiar attraction of the masses on which we operate, since this would require the knowledge of their relative density, and even of the arrangement of the materials which enter into their composition. But, as we cannot avoid this uncertainty, we must endeavour to render it as small as possible, by making our observations as near the level of the sea as we are able. We must then recollect, that, by ascribing at the highest station the whole of the force of gravity to the sole and distant action of the earth, we suppose it to be more powerful than it really is. So that, by reducing it on this hypothesis, to what it would really be if it had been observed at the level of the sea itself, we commit a double error; the mountain's own attraction tending, in this second case, by its contrary direction, to weaken the effect of gravity, which it had before augmented. Fortunately, the excessive smallness of the highest mountains, compared with the mass of the globe, must diminish extremely their relative influence, and render equally minute the errors which may arise from neglecting it.

To determine, now, the coefficients A and B of the general formula, we shall employ the oblateness 0.00326, or $\frac{1}{306.75}$, which M. La Place has obtained by submitting to a general and profound discussion, the measures of the terrestrial degrees, and the lunar equalities depending on the oblateness of the earth. We shall join to it the length of the simple pendulum of sexagesimal seconds, found by Biot at the station of Unst, a length which, we think, may be considered as one of the most certain that has been observed. *First*, because having been the last of the observations made by Borda's method, it must have been taken with all the precautions suggested by preceding experiments. *Secondly*, on account of the great number of series from which it results, these being 56 in number, and made with different rules, and pendulums of unequal lengths, which all agreed in assigning for the definitive result values differing excessively little from each other. And,

Lastly, from the perfect agreement which is found between it and the results of the observations of Captain Kater. This single absolute length, together with the oblateness 0.00326, will suffice for determining the two constant quantities A and B of the general formula, which expresses the length of the pendulum at any latitude. Now, according to this formula, the length of the pendulum at the equator, where L is nothing, is equal to A, and at the pole, where $L=90^0$, it is A+B. So that $\frac{B}{A}$ is the relation of the total variation of the pendulum to its absolute length at the equator; a ratio which is the same as that of the increments of gravity to the absolute force of gravity itself. Adding, then, $\frac{B}{A}$ to the oblateness 0.00326, we shall have, by the theorem of Clairault, the following condition, $\frac{B}{A}+0.00326=0.00865$, whence we obtain B=A.0.00539, and, consequently, $\lambda=A\,(1+0.00539.\sin^2 L)$. Now, we have seen above, that at the station of Unst, in latitude 60° 45′ 25″, the length of the sexagesimal seconds pendulum determined by the observations of Biot, was $\overset{mm}{994.943105}$. The height of this station was only 9^m above the level of the sea, which gives for the reduction $+0.^{mm}002818$. Whence there results, at the level of the sea, the height $\overset{mm}{994.945923}$. Putting this value, then, and that of L in the formula, the coefficient A, is determined, and we find $A=\overset{mm}{990.879660}$. consequently B=5.340843; which gives for any latitude L,

$$\lambda=\overset{mm}{990.879660}+\overset{mm}{5.340841}\sin^2 L.$$

If we wish to reduce this formula in English inches, all the terms must be multiplied by $\frac{39.37079}{1000}$, and then

$$\lambda=\overset{in.}{39.0117150}+\overset{in.}{0.2102732}\sin^2 L.$$

Finally, if we wish to reduce it to the decimal pendulum employed by the French observers in their calculations, we must multiply the terms by $\left(\frac{864}{1000}\right)^2$, the ratio of the decimal to the sexagesimal pendulum. We then have

$$\lambda=\overset{mm}{739.687686}+\overset{mm}{3.986917}\sin^2 L.$$

If we calculate from this last formula, the lengths of the decimal pendulum, for the stations where the French observers have operated, from Formentera to Unst, and compare them with their results, we obtain the following table.

Names of the Places.	Names of the Observers.	North Latitudes.	Length of the Decimal Pendulum at the Level of the Sea, By Calculation.	By Observation.	Excess of Calculation.
			mm	mm	
Unst, . . .	Biot	60° 45′ 25″	742.723136	742.723136	0.000000
Leith Fort, .	Biot, Mudge	55 58 37	742.426416	742.413435	+0.012981
Dunkirk, . .	Biot, Mathieu	51 2 10	742.098066	742.077030	+0.021036
Paris, . . .	Biot, Mathieu, Bouvard	48 50 14	741.947360	741.917490	+0.029870
Clermont, . .	Biot, Mathieu	45 46 48	741.735412	741.705180	+0.030232
Bourdeaux, .	Biot, Mathieu	44 50 26	741.670048	741.608720	+0.061328
Figeac, . .	Biot, Mathieu	44 36 45	741.654181	741.612280	+0.041901
Formentera, .	Biot, Arago, Chaix	38 39 56	741.243950	741.252000	—0.008050

The progression of the deviations contained in the last column of this table shows, in proceeding from the north to the south, a progressive decrease of gravity, greater in a slight degree than the elliptical figure requires; a result which had already been remarked in regard to Scotland and England by Captain Kater. It may be observed here, that the absolute value of this variation for Unst, Leith, and Dunkirk, agrees exactly with that which Captain Kater has found, or what could be deduced from his experiments. But the same effect is observed to continue throughout France, being most sensible at the station of Bourdeaux. It becomes less even at Figeac, situated more inland, and on a more solid base. It again becomes nothing at Formentera, where the deviation of the formula compared with observation is $\frac{8\,mm}{1000}$ in a contrary direction, which would seem rather to indicate a slight local excess in the intensity of gravity. This singular anomaly, which is so stated, in regard to the force of gravity, throughout the terrestrial arc which extends over all this part of Europe, is, without doubt, owing to peculiarities in the geological constitution of the countries which are situate on it; and it appears by this example, how well the observations of the pendulum are adapted for pointing out the irregularities of this constitution. But, for this purpose, the observations must possess so great a degree of exactness that the peculiar uncertainties to which they are liable may be, as we may suppose they were in those which we have employed, much smaller than the variations of constitution which they are intended to indicate. Here it may be remarked, that the part of France, where these variations are the most sensible, are precisely the same where there were found, by Delambre's observations, the greatest anomalies in the lengths of the degrees.

From the preceding formulæ may be deduced the variation in the diurnal rate which a compound pendulum, of an invariable form, must present when carried to different latitudes. If we denote by N, N′, the number of oscillations of this pendulum at two different stations, where the lengths of the simple seconds pendulum are λ, λ', we have shown above that $\frac{\lambda'}{\lambda}=\frac{N'^2}{N^2}$, whence $N'^2=\frac{\lambda'}{\lambda}.N^2$. Now, calling L, L′ the latitudes of the two stations, the above formulæ give the values of λ and of λ', as well as their relations; substituting, then, these values in the preceding equation, we obtain $N'^2=\frac{A+B\sin^2 L'}{A+B\sin^2 L}N^2$. An expression by means of which we can calculate N′ when we know N.

The total variation of gravity from the equator to the pole is so inconsiderable, that the difference between the numbers N, N′ is always very small compared with these numbers themselves. This difference, then, is the element which we must try to put in evidence in the formulæ. But nothing is easier; for, if we denote it by n, so that N′ is represented by $N+n$, the preceding equation will become $N^2+2n\,N+n^2=\frac{A+B\sin^2 L'}{A+B\sin^2 L}N^2$.

Whence we deduce

$$2nN+n^2=\frac{B\sin(L'+L)\sin(L'-L)}{A+B\sin^2 L}.N^2,$$

and resolving the value of N into a series,

$$n=\left\{\begin{array}{l}\dfrac{B\sin(L'+L)\sin(L'-L)}{2(A+B\sin^2 L)}.N\\ -\dfrac{B^2\sin^2(L'+L)\sin^2(L'-L)}{8(A+B\sin^2 L)^2}.N\ldots\&c.\end{array}\right\}$$

But from the value of the oblateness which we have adopted, we have seen that B is equal to A. 0.00539. Substituting this value in our series, it becomes

$$n=\left\{\begin{array}{l}\dfrac{0.00539.N.\sin(L'+L)\sin(L'-L)}{2(1+0.00539\sin^2 L}\\ -\dfrac{0.000029N.\sin^2(L'+L)\sin^2(L'-L)}{8(1+0.00539\sin^2 L)^2}..\&c.\end{array}\right\}$$

The second term will be almost always insensible, and it will be quite needless to take in any of the following ones.

To show the use of this formula, we shall apply it to the following observations, which belong to the most distant countries on the earth.

Names of the Observers.	Names of the Stations.	Longitudes, reckoned from Greenwich.	Latitudes.	Number of Oscillations performed by the Compound Pendulum in a Sidereal Day, or in a Mean Solar Day, at the same Temperature.	Variation of the Diurnal Rate, by Observation.	Variation of the Diurnal Rate, by Calculation.	Excess of Observation.
G. Graham & C. Campbell, in 1731 & 1732,	Jamaica, .	76° 45′ 15″ W.	18° 0′ 0″ N.	86283.0	118″2	119″96	—1″76
	London, .	0 0 0	51 31 0 N.	86401.2			
Maupertuis, Clairault, Lemonnier, 1738,	Paris, .	2 20 15 E.	48 50 14 N.	86394.4			
	Pello, .		66 48 0 N.	86453.5	59 1	64 70	—5 60
Graham, 1738,	London, .	0 0 0	51 31 0 N.	86402.1	51 4	53 85	—2 45
Freycinet, .	Paris, .	2 20 15 E.	48 50 14 N.	89143.8			
	Rio Janeiro,	43 18 37 W.	22 55 2 S.	89048.8			
	Cape of Good Hope,	18 24 0 E.	33 55 15 S.	89086.4	95 0 57 4	99 43 61 10	—4 43 —3 70
Sabine, 1818,	London, .	0 0 0	51 31 8 N.	86497.40			
	Brassay, .		60 9 42 N.	86530.51	33 11	31 82	+1 29
	Hare Island,		70 26 17 N.	86562.64	65 24	62 46	+2 78
Sabine, 1820,	London, .	0 0 0	51 31 8 N.	86455.65			
	Melville Island.	110 49 0 W.	74 47 14 N.	86530.38	74 73	73 93	+0 80

The experiments of Captain Sabine were made with two pendulums applied to two different clocks, the results of which have agreed very well in their relations. We have only stated here the mean of these results. The observations of Maupertuis, Clairault, and Lemonnier, were made by a process of the same kind, but with a single clock by Graham. In these two expeditions the observers produced artificially at the second station the same temperature as at the first. In the operation by Campbell, the same pains were not taken; but in Bradley's computations, an allowance was made according to the indications of the thermometers. The experiments of Captain Freycinet were made on detached pendulums, the rate of which, first determined by Arago, Mathieu, and himself, at the Royal Observatory of Paris, was compared in the voyage with well regulated chronometers, making allowance, by calculation, for the changes of temperature. The smallness and the irregularity of the differences which are found be-

tween the results of these different experiments, and the numbers given by the formula, show that the latter is the general expression of them, modified only by the accidental variations which may be occasioned in each place by small differences of density in the neighbouring strata of the surface of the earth. The formula being grounded upon the oblateness 0.00326, or $\frac{1}{326.75}$, its agreement with the facts proves that this value of the oblateness, if not rigorously exact, is at least a very near approximation, and is, besides, common to the two hemispheres of the globe, since the observations of Captain Freycinet in the southern hemisphere, at the Cape of Good Hope, are as correctly represented by it as the observations made in the northern hemisphere. This puts an end, then, to the notion entertained after the measurement of the degree by Lacaille in this part of the globe, that the southern hemisphere was more oblate than the northern; a notion, however, already much weakened by the agreement of the oblateness observed in this latter hemisphere with that which was deduced from the inequalities of the moon; since the motion of this satellite must be influenced by the mean of the two ellipticities if they were different; but it was nevertheless of consequence to see this suspicion wholly extinguished, as it is now by Freycinet's observations.

The general experiments on the length of the pendulum which we have above described, being verified by the different observations by which we have compared them, will serve to determine the intensity of gravity, whether absolute or relative, on any of the places of the terrestrial globe. For, calling λ the length of the simple pendulum, which makes its oscillations in a second of time in a given place, and denoting by g the double of the space which gravity makes bodies describe in their fall in the same place, and during the same interval of a second, the fundamental formula of oscillations, infinitely small, gives $1''=\pi\sqrt{\frac{\lambda}{g}}$, consequently $g=\pi^2\lambda$, π being the ratio of the circumference to the diameter, or 3.14159. But we have already given for any latitude the value of λ expressed in millemetres and in English inches, taking for the unity of time either the decimal or the sexagesimal second. Multiplying these expressions by the square of π, we shall have the value of g for the same latitude, and the same kind of unity of time which may be chosen.

It may be objected, that we have not made use of the lengths of the simple pendulum observed under the equator by Bouguer, and detailed in his work on the figure of the earth. The reason is, that, notwithstanding of the ability of Bouguer, as a philosopher and an observer, and the infinite pains which he took in his measurements of the pendulum, it appears to us, on account of the nature of the processes he made use of, that they are too inexact to be employed with advantage. The method of Bouguer consisted in forming a sort of simple pendulum, with a very small weight suspended to a stem, the other extremity of which was attached to a pincer fixed into a solid wall. He made this little pendulum always of the same length, by comparing it with an iron rule, which served him for a standard; after which he determined the value of its oscillations by comparing its rate with that of a clock regulated by the heavens. But M. La Place has justly remarked, that the bending of the stem at the point of suspension, where it is inserted into the pincer, must produce the same effect on the oscillations as a contraction in the wire; so that the length, measured in a state of repose, must be too great, and would appear to give the pendulum too long. This effect, indeed, must have been produced on all the lengths given by Bouguer, since they were all observed in the same manner. From that it would seem that these observations might at least be employed in comparison with each other, and in that case, give exact ratios. But the process by which Bouguer judged of the length of his little pendulum, and compared it with his standard rule, appears to us not accurate enough for giving a sufficient certainty in his results. For it consisted in laying this rule close to the pendulum, placing its upper end in contact with the point, and judging of its equality by the eye, in comparing it with the pendulum at its lower extremity. But no one, by such an operation, can answer for an exactness greater than $\frac{5}{100}$ of a line. Now $\frac{5}{100}$ of a line being equal to $\frac{1}{10}$ of a millimetre, such an error, with the methods now actually employed, would be accounted gross, and such indeed as, with the least attention, it is quite impossible to commit. These results cannot then be compared with the observations which are made now; and, unfortunately, the same remark applies with equal justice to the measurements of the absolute lengths of the pendulum which were made about the same period, as well in France as in various other parts of the globe. We think it extremely probable, that to the want of exactness in the methods employed at that time may be ascribed, at least in a great measure, the strange anomalies observed by Grischow in the lengths of the pendulum, in the neighbourhood of Petersburgh, between stations very little distant from each other; anomalies so much more justly suspected, since the different instruments employed by Grischow to establish them are far from agreeing with each other. Nevertheless, for removing entirely all suspicion with regard to a point so important, it would be a useful undertaking to repeat these experiments in the same places where Grischow's observations were made; employing for this purpose our present much more accurate methods. (Z. Z.)

Fig. 8.

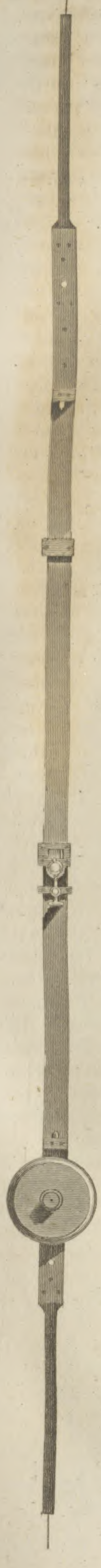


Fig. 1.

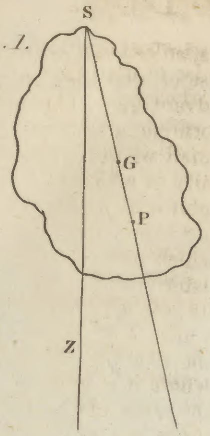


Fig. 4.

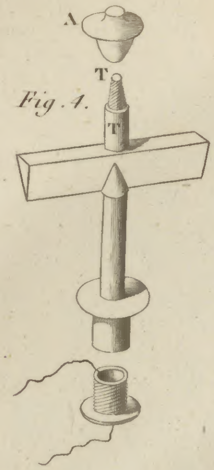


Fig. 3.

Fig. 2.

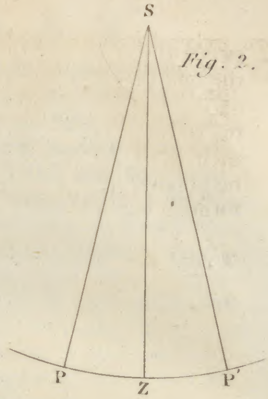


Fig. 6.

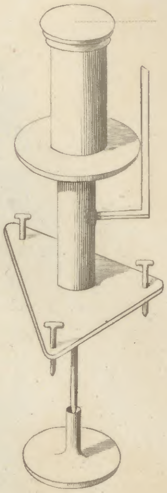


Fig. 5.

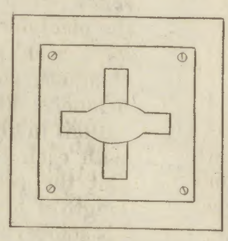


Fig. 7.

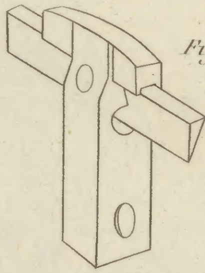
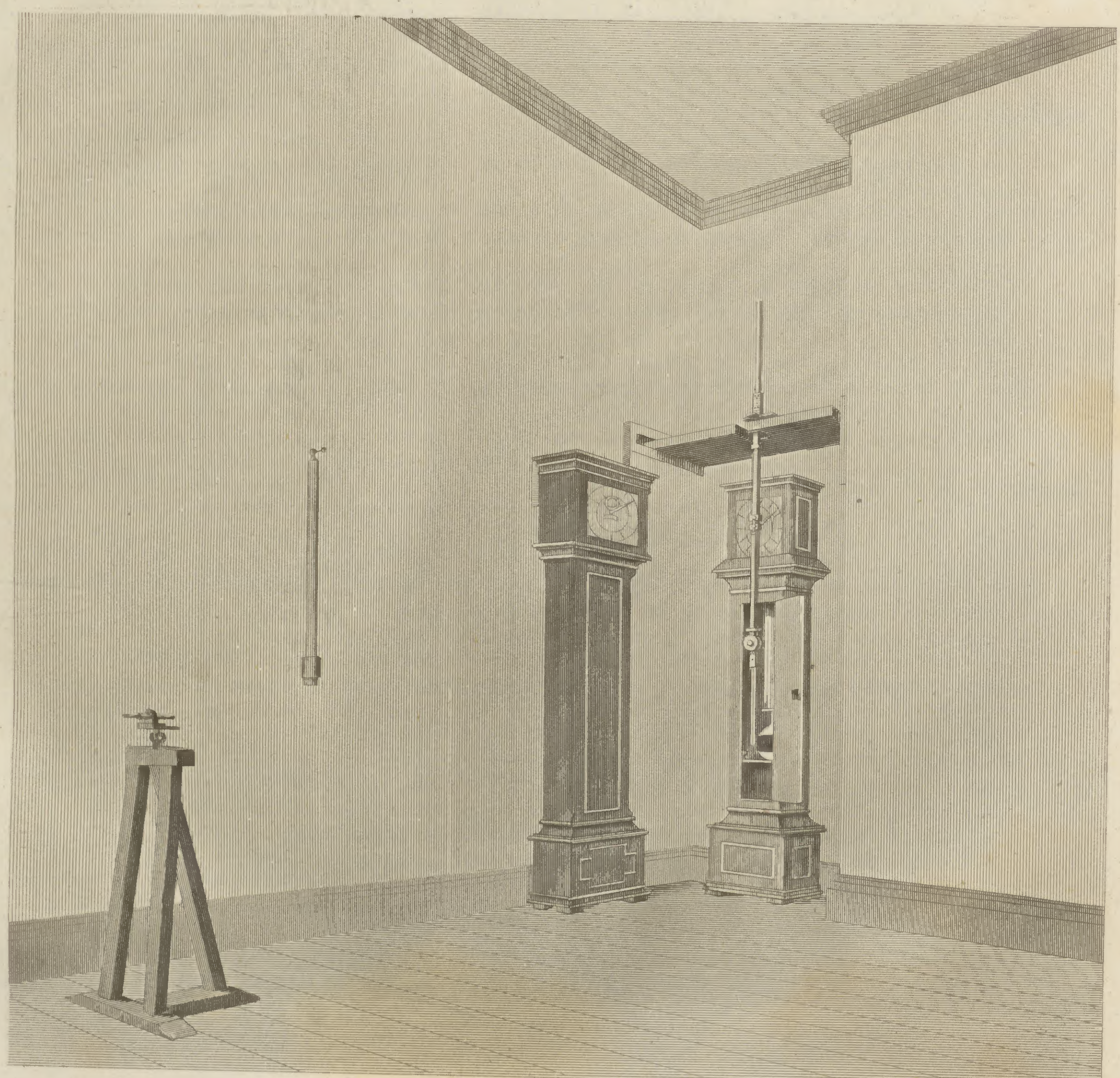


Fig. 9.



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Perthshire.

PENITENTIARIES. See PRISON DISCIPLINE.

Situation, Extent, and Divisions.

PERTHSHIRE, a county in Scotland, having the shire of Inverness and Aberdeen on the north; Angus or Forfar, Fife, and Kinross, on the east; Clackmannan and Stirling on the south; and Dunbarton and Argyle on the west; contains, according to the latest authorities, 2638 square miles, of which 50 are occupied by lakes; or, in all, 1,688,320 English acres; being, next to Inverness-shire, the largest county on the mainland of Scotland. It is situated between 56° 7′ and 56° 35′ north latitude, and between 3° 6′ and 4° 47′ west longitude, from Greenwich. Its greatest extent, from east to west, is about 77 miles, and from north to south 68. It was anciently, and is still, popularly divided into eight districts: Atholl on the north, Stormont on the north-east, Perth Proper and Gowrie on the east, Strathearn on the south, Monteith on the south-west, Breadalbane on the west, and Rannoch on the north-west. It is under the jurisdiction of one sheriff, who has substitutes in the towns of Perth and Dunblane, and is divided into seventy-nine parishes.

Surface.

In a general view, this extensive county may be divided into Highlands and Lowlands; the former occupying a space so much greater than the latter, that not quite so much as a third part of the whole is fit for cultivation. This last portion is chiefly, though not without considerable exceptions, situated on the eastern and southern extremities, which contain some of the richest tracts in Britain; and in the great plain of Strathmore which has the Grampians on the north-west, and the Ochils and Sidlaw Hills on the east; varying in breadth from ten to fifteen miles, and extending through this and the contiguous counties, from sea to sea, a distance of 100 miles. To the west, where the Grampians, at first rising gently, rear their rocky or heath-covered summits to the height of 4000 feet, and for almost the whole breadth of the county, the high grounds are penetrated by straths and glens, some of them of considerable extent, each traversed by its own mountain streams, and diversified by numerous lakes, many of which, having their wild and lofty banks covered with natural wood, present scenes singularly romantic and beautiful. At least seven of these mountains are upwards of 3000 feet high: the three highest being Benlawers, on the west side of Loch Tay; Benmore, south-west; and Schehallion, north-east: the latter noted as the station chosen by Dr Maskelyne, Astronomer Royal, to make observations on the attraction of mountains. The most considerable lakes are—Loch Tay, almost in the centre of the Highland district, about fifteen miles long, and one broad, with a depth varying from fifteen to one hundred fathoms; Loch Ericht, on the north-west, extending into Inverness-shire, still longer, but not so broad; Loch Rannoch, south-east of the former, twelve miles long; Loch Earn, south from Loch Tay; and Lochs Vennachar, Achray, and Katrine, on the south-west: the last of which, with the wild mountain scenery around it, called the Trosachs, has acquired deserved celebrity, from Sir Walter Scott's *Lady of the Lake*. Most of the streams either have their source in these lochs, or receive, as they flow through them, a great accession to their waters. The rivers are the Tay, the Forth, the Earn, the Teath, and the Isla; of which the two first are by far the most considerable, though the Forth does not attain its full size till it has left this county. The Tay, the largest river in Scotland, and the Earn, belong exclusively to Perthshire. The Tay, under the name of the Dochart, has its source on the western confines, and soon after entering Loch Dochart, flows from thence north-east till it falls into Loch Tay. After leaving Loch Tay, from which it now takes its name, it pursues first a north-easterly aud then a southerly course towards Dunkeld, from which it proceeds eastward, and then south, through a very rich country, till it falls into the Frith of that name, a little below the town of Perth; having been joined by the Almond and many other streams in its course, which, with all its windings, is not less than ninety miles. The salmon fishery on this river yields a rent of about L. 7000 a-year. South of Loch Tay is Loch Earn, where the river of that name has its source, and which, flowing east and south, through Strathearn and by the town of Crieff, after a course of twenty-four miles, falls into the Frith of Tay at Rhind. On the banks of this river, near its confluence with the Tay, is the village of Pitcaithly, long celebrated for its mineral springs, which have lately found a rival at Dunblane, on the southern side of the county.

Perthshire. Rivers.

Climate.

The climate of this extensive district, so different in elevation and exposure, varies considerably. In the central parts, the winters are stormy and very severe, the snow lying long, attended with keen frost; and on the banks of the rivers in this quarter, hoar-frosts are frequent in summer, and very injurious to the crops. On the east, the climate is mild and salubrious. At Longforgan, in the Carse of Gowrie, on the banks of the Frith of Tay, the thermometer, on an average of twelve years, stood at 50°, and the mean annual quantity of rain was 24.496 inches; and at Belmont, in Strathmore, for a period of ten years, the average height of the thermometer was 46.35, and the yearly quantity of rain during thirty years' observation 30.40 inches.

Minerals.

Perthshire, as far as yet known, does not abound in useful minerals. There is no coal but at Culross, on a small detached tract lying on the Forth, south-east from the rest of the county; and, for want of coal, limestone, which is found in many parts, is of little value, though it is sometimes imperfectly calcined by means of peat. Some years ago, a machine was erected for pounding limestone, with the view of employing it in that state as a manure; but the experiment was not persisted in. In the higher grounds, the prevailing rock is granite, and in the lower sandstone. Slates are found in many parts of the Highlands, but none in the low country. Copper, lead, and ironstone, occur in some parts; and mines of the two former were once worked, but are now abandoned. Shell marl, which has been long used as a manure, abounds in Stormont and Strathearn, on the east side of the county.

Soil.

On so great a variety of surface, every description of soil occurs that is found in Scotland. That which distinguishes this district, though it is not peculiar to

Perthshire. it, is the alluvial soil on the banks of the rivers, which is of considerable extent, and in many parts of the richest quality. The Carse of Gowrie, in particular, a tract of about 18,000 acres, lying along the north and north-west banks of the Frith of Tay, has been long celebrated for its fertility. Here there are upwards of twenty orchards, of all sizes, from one to twenty-four acres each. Perthshire has all the kinds of game common in other parts of the Highlands of Scotland, with red and fallow deer, and roes, rabbits, pigeons, and poultry.

Estates and Seats. The territory of Perthshire was divided, in 1811, into 755 estates, of which 621 were under L. 500 Scots of valuation, and 95 above L. 2000; the valuation of the whole being L. 339,892, 6s. 9d. Scots, the highest of any of the Scottish counties excepting Fifeshire. The real rent, as returned under the Property-Tax Act in 1811, was, for the lands, L. 460,738, 13s. 11d. Sterling, and for the houses, L. 36,697, 19s. 7d. This land-rent, which is more than that of any of the other counties by almost one-third, is equal to about a tenth part of the rent of all Scotland; yet it is only at the rate of about 5s. 6d. the English acre. In the same year, the number of freeholders entitled to vote in the election of a member for the county was 178. There are more oak-woods, and these of a greater value, here than in all the rest of Scotland, and very extensive plantations of all sorts of trees, particularly larch, have been made within the last 50 years; of which, those of the Duke of Atholl are of great extent, and now of immense value. The county is much ornamented by the numerous seats of the proprietors, of whom 12 or 13 are noblemen. Among these are Blair Castle and Dunkeld House—Duke of Atholl; Taymouth—Earl of Breadalbane; Scone—Earl of Mansfield; Dupplin Castle—Earl of Kinnoul; and Dunira—Lord Melville.

Farms. The general size of the farms in the Lowlands is from 100 to 300 acres. In the Highlands, the same system prevails that we have adverted to in describing the other Highland counties of Scotland; though here, as elsewhere, it is slowly giving way to one better adapted to the present times. In the crops, live stock, and general management of farms, we find nothing peculiar, except, perhaps, that flax is cultivated to a greater extent than in the southern counties of Scotland. On the Carse of Gowrie, the highest rented land of the same extent in Britain, if we except the immediate neighbourhood of a few great towns, the order of cropping, after a plain fallow is—wheat, beans, and pease, barley with seeds, hay, and oats; and under this course, some of the best land yielded, so far back as 1795, a money-rent of 31s. with three bushels of wheat, and about four and a half bushels of barley—altogether, at the prices during the late war, equal to four guineas the Scots acre.

Towns. This county has only two royal burghs, Perth the county town, and Culross. Perth is a place of great antiquity, formerly the usual residence of the Scottish sovereigns, who were crowned at Scone in its vicinity, and the seat of parliaments and courts of justice. Some of the most important events in Scottish history, both of a religious and military description, occurred here. (See the article PERTH in the *Encyclopædia.*) It is now a well built thriving town, containing (in 1811) about 17,000 inhabitants. About 70 other towns and villages are scattered over the county, the most considerable of which have been already described in the *Encyclopædia.*

Manufactures and Commerce. The manufactures of Perthshire are linen, cotton, leather, paper, and a variety of minor articles. It has extensive bleachfields, printfields, and cotton-mills, with mills for extracting oil from the seeds of flax and rape, and for the spinning of flax and wool. Its exports are corn, linen and linen-yarn, cottons, boots and shoes, salmon, with coals from the ports of Kincardine and Culross on the Frith of Forth; and it imports some of the materials of its manufactures, lime in great quantities, and articles required for domestic consumption. In 1806, there belonged to the port of Perth 35 vessels, of 2635 tons in all, with 153 seamen.

Representation. The county of Perth sends one member to Parliament; and the towns of Perth and Culross have a share in the election of other two for the burghs; Perth being classed with St Andrews, Cupar Fife, Dundee, and Forfar; and Culross with Stirling, Dunfermline, Inverkeithing, and Queensferry.

The population, according to the census of 1801 and 1811, is exhibited in the following abstract.

See the general works quoted under the former Scottish counties, and Robertson's *General View of the Agriculture of Perthshire.*

(A.)

1800.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Persons* chiefly employed in Agriculture.	*Persons* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Persons* not comprised in the two preceding classes.	Total of Persons.
23,382	28,971	952	58,808	67,558	24,404	22,773	76,885	126,366

1811.

HOUSES.			PERSONS.		OCCUPATIONS.			
Inhabited.	By how many *Families* occupied.	Uninhabited.	Males.	Females.	*Families* chiefly employed in Agriculture.	*Families* chiefly employed in Trade, Manufactures, or Handicraft.	All other *Families* not comprised in the two preceding classes.	Total of Persons.
26,404	29,998	886	64,034	71,059	8,528	11,721	9,749	135,093

PERU.

THE name of this country has been so long associated, in the minds of Europeans, with the idea of prodigious wealth, that it has created an interest very far beyond its real importance, either as a colony of Spain, or as the future theatre of a great independent state.

The early history of the conquest of Peru by Pizzaro and his associates, the vast plunder which was shared amongst them, the dissensions which prevailed after the extirpation of the family of the former sovereigns, and the ultimate tranquillity into which the country settled under the colonial administration of Spain, have been fully narrated in the *Encyclopædia;* and there only remains in this *Supplement* the duty of communicating such statements of the more recent and actual state of Peru, as shall bring down to the present period the account given of it in that work; and to correct those errors which a paucity of materials, in general circulation, were likely to produce.

Boundaries and Extent.

When Peru was first reduced to the obedience of the Crown of Spain, it was the largest of any of the governments founded in America. It has since been reduced, at two periods, in order to give such extension to other provinces, as should entitle them to the rank of viceroyalties. In the year 1718, the province, or, as it is sometimes called, the kingdom of Quito, was separated from Peru, and added to the government of New Granada. In the year 1778, when the Court of Madrid had resolved on erecting the province of Buenos Ayres into a viceroyalty, the province of Potosi, the district surrounding it, the cities of La Paz, La Plata, and the fertile district of Cochabamba, were separated from Peru, to form a part of the newly extended government. As, during the civil wars, which have raged from 1810 to the present time, those provinces have been wrested from the dominion of Spain, they are likely, in future, to appertain to that division of South America which will be included in the territories of Buenos Ayres or La Plata, rather than to that which will include either Peru or Chili.

The present boundary of Peru to the north is the small river Tumbez, in latitude 3° 26′ south, and longitude 80° 6′ west from Greenwich; which river divides it from New Granada. To the south the boundary is the chain of mountains of Vilca-Nota, which terminates at the river Loa in latitude 15°. The extent of the coast of Peru is thus about 700 geographical miles, but as the sinuosities of the shore are considerable, the whole frontage to the ocean is upwards of 1000 miles. The eastern boundaries of Peru are not clearly defined. They extend to the vast plains claimed by Portugal, as a part of Brazil, denominated the *Pampas del Sacramento*, and farther north to Colonna, or the Land of the Missions, inhabited by unreclaimed Indian tribes. The medium breadth is about 80 leagues, according to Humboldt, who estimates the whole area of Peru to be 30,000 square leagues.

First District.

The lands of Peru may be divided into three classes, according to their height above the sea. A narrow strip of sandy plain bounds the whole western coast, with intervals of many leagues between the different towns and cities, in which neither inhabitant nor any traces of vegetation are visible. It is only where the torrents from the high lands form rivers, which are few in number, and of short course, that any agricultural productions are raised. Under this sandy soil, however, springs are in general to be found, whilst the surface is most strongly impregnated with nitre. As far as the cultivation of this district extends, it is powerfully aided by a species of manure which is peculiar to the coast of Peru, whose fertile qualities seem to be derived from the singular circumstance of no rain falling there. On the islands, which are the resting-places of millions of aquatic birds, their dung has accumulated in the course of ages, so as to form hills of more than 100 feet in height, close to the shore; from whence it is conveyed by small vessels to the parts of the mainland where cultivation is practised. The dung thus collected, not having its salts washed by rain, and being but slightly affected by the rays of the sun, has retained, as appeared by the analysis of Sir Humphrey Davy, a greater portion of ammonia than any substance that has been applied to the purposes of manuring land. The quantity that is administered by the Peruvians is minutely small, and unless diluted, never suffered to come in contact with the roots of the plants which are designed to be raised. Its fructifying powers, as described by those who have witnessed its effects, especially when applied to the different species of *capsicums*, which form the chief food of the more numerous classes, exceed every thing that has been related of any other stimulant.

On the track of land we are describing, varying in breadth from six to about twenty leagues, little or

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no rain ever falls, and thunder and lightning are unknown. The lofty mountains to the eastward intercept the clouds from the Atlantic Ocean, and the constant winds from the south drive the clouds that collect in the Antarctic Circle beyond the limits of Peru before they discharge their waters. Although no rain falls in this district, commonly distinguished as "Lower Peru," the dew that descends during the night is very heavy, and uniform. The constant evaporation that is thus going on produces a haziness in the atmosphere, and the sun seldom appears with that brilliancy which it displays in the higher levels. The heat is seldom so intense as to prevent the labourers from working in the open air, and the thermometer rarely rises to above 75 degrees. The medium height through the year, in which there is little variation, is about 64°.

In this district are produced most of the tropical plants. The plantain, banana, pine-apple, sugar-cane, vine, cocoa, olive, coffee, and cotton, as well as the most delicious fruits, some, such as the chiremoya and the frutilla, peculiar to the country, arrive at great perfection.

Second District.

The next division of Peru consists of that range of the Andes nearest to the Pacific Ocean, commencing generally with hills of moderate elevation, but in some parts with bold projecting and abrupt precipices. The sides of these hills are covered with forests, rendered almost impenetrable by the numerous parasitical plants which twine round the lofty trees; and whilst, by their verdure, they give beauty to the scenery, prevent the access of visitants until a path is cut by severe labour. These forests afford acacias, mangle trees, arborescent brooms, and ferns; aloes and other succulent plants; cedars, cotton, or Cuba trees of gigantic magnitude, many kinds of ebony, and other useful woods, many species of palms, and the maria, a tree of enormous size, used in ship-building. The valleys between these hills afford most of the trees which are natives of the tropics; few of them are well calculated for the purposes of building.

The district called Higher Peru, commencing at the termination of the sands on the shore, continues increasing gradually in height towards the eastward, till the ridge of the Andes or the Cordilleras is attained.

The line of perpetual snow is about 14,000 feet above the level of the sea, and from that line upwards vegetation necessarily ceases; below it the plants, by regular gradations, display the nature of the climate, and its adaptation to the various families of vegetables; and, in different parts, exhibit every species of production which can be found from the dwarf plants of Lapland, to the odoriferous spices of Sumatra.

This portion of Peru contains the sources of those vast rivers which traverse the whole continent of South America. Their streams, for the most part, run to the Atlantic Ocean. The few that run to the Pacific are of short course, and do not yield copious supplies. It has been said, with what degree of accuracy it would be difficult to determine, that the river Thames conveys to the sea a greater supply of water than is emptied into the Pacific by all the rivers of Peru. The rivers, on the other hand, which empty themselves into the Atlantic, are the greatest on the face of the globe. The Magdalena, the Meta, the Orinoco, and the Amazons, commence in this portion of the Andes, take varying and most tortuous courses in descending from the heights, and, having collected in their progress augmented supplies, at length reach the vast plains through which they flow to the Carribean Sea and the Atlantic Ocean.

Though many of the plains in this mountainous district possess most fertile soils, and climates admirably adapted to raise food for man; yet, from the difficulty of access to them, and the consequent expence of conveyance, they are merely cultivated to a sufficient extent to provide food for the inhabitants of their immediate vicinity. Although Lower Peru is nearly destitute of wheat, and deficient in other grain, instead of drawing the supply it needs from the more temperate regions of the vice-royalty, it is chiefly fed with corn sent by sea from Chili.

This mountainous district is the chief seat of the mineral wealth of Peru. The mines are, for the most part, situated at great elevations, and consequently in a climate so severely cold, as to be unfavourable both to the health of the labourers, and to the raising food for their subsistence. The most abundant silver mines, those of Pasco and Huancavelica, are between 13,000 and 14,000 feet above the level of the sea.

Third District.

The third district of Peru commences on the eastern summit of the Andes, and proceeds eastward till it reaches the territories of Portugal, towards their northern part; and the provinces of La Plata, or Buenos Ayres, towards the south. The descent from the Andes, on the eastern, is much more abrupt than on their western side. They terminate in vast plains called sometimes *Pampas del Sacramento,* or more usually, collectively, *Colonna*, or the *Land of the Missions.* The Jesuits succeeded in collecting in villages many of the rude inhabitants of this country; and, according to the relation of one of that body, Father Girval, the tribes are numerous, small, and scattered; with as many various languages as tribes, and differing much from each other in the degree of civilization to which they had attained. These Pampas are represented as being covered with trees and verdure, and yielding balsams, oils, gums, resins, cinnamon, cocoa, cascarilla, and many valuable drugs, spices, and other rare productions. The trees are lofty, and form impenetrable forests, in which wander all the animals peculiar to the torrid climate of America. The heat is excessive, and accompanied with such humid fogs, as to be a most miserable residence for these missionaries, whose zeal for the conversion of the natives led them to penetrate into such wilds.

Amidst the various circumstances which distinguish Peru, there are some, of the most calamitous and terrific nature, of which all parts partake, and in a long series of years in almost equal degrees. The whole country is subject to the most violent convulsions of nature. Earthquakes are frequently felt in every part; and are sometimes accompanied with most extensive and fatal effects. The lofty chain of the Andes is a collection of volcanos, some in constant activity, others occasionally ejecting inflamma-

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Population.

ble substances; while there are many whose fires, in the lapse of ages, seem to have been burnt out. The annexed TABLE, taken from an ecclesiastical census, contsins a view of the population of Peru, and of the classes into which it is divided; exhibiting also the proportions of the sexes.

Peru.

Intendencies.		Number of Departments.	Missions.	Pueblas or Parishes.	Clergy.	Male Religious.	Female Religious.	Nuns.	Spaniards.	Indians.	Mustees.	Free Negroes.	Negro Slaves.	Total.
Lima, - -		8	74	181	431	1100	572	84	22,370	63,181	13,747	17,864	29,763	149,112
Cuzco, -		11	102	134	315	474	166	113	31,828	159,105	23,104	993	284	216,382
Arequipa, -		7	60	84	326	284	162	5	39,357	66,609	17,797	7,003	5,258	136,801
Truxillo, -		7	87	149	460	169	162	0	19,008	115,647	76,949	13,757	4,725	230,967
Humanga, -		7	59	135	176	45	82	0	5,378	75,284	29,621	943	30	111,559
Huancavelica,		4	22	88	81	18			2,431	23,899	4,537		41	30,917
Tarma, - -		7	79	206	229	127		15	15,939	105,187	78,682	844	236	201,259
Totals,		51	483	977	2018	2217	1144	217	136,311	608,912	244,437	41,404	40,337	1,076,997
Division of Sexes,	Males, -				2018	2217			67,325	293,061	115,581	19,906	21,592	521,700
	Females, -						1144	217	68,986	315,851	128,856	21,498	18,745	555,297

This table is confirmed by one returned to the Viceroy in 1803; as the difference does not amount to more than 850 souls. Although the number of Spaniards is stated at 136,311, nearly one-eighth of the whole population; it must be considered, that in this number is included those who, after five mixtures with the white race, acquire the privileges of whites, though their complexions are as dark as those of the Indians or Negroes. Of those denominated Spaniards, it is not estimated, that one-tenth are natives of Europe. The great mass of the population consists of the original Peruvians, usually called Indians by the Spaniards; and of the descendants of their females by white fathers, called Mustees. The former of these, for the most part, live in towns or villages by themselves, or when they are established in the larger places, have separate quarters assigned to them. They have magistrates, and usually clergy of their own race. They are not subject to the Inquisition, pay none of the taxes to which the other inhabitants are liable, nor have any duties imposed on them, except that of furnishing a certain number of labourers for the mines; for which they are so well paid, that the employment is rather an object of desire than aversion; and those who are once destined to it, most commonly become constant miners. They pay, indeed, a small capitation tax, which exempts them from all other imposts, and is considered rather as a mark of distinction betwixt those settled among the Spaniards, and those unreclaimed tribes who are denominated *Indios infideles.* The average net amount of the Indian tribute is about 520,000 dollars, a little more than L.100,000 annually.

The Peruvians seem to have degenerated since their subjection. They appear timid, dispirited, and melancholy in their temperament, but severe and rigid in the exercise of their authority; wonderfully indifferent to the general concerns of life, and neither anxious nor careful to avoid death. They stand in awe of their white masters, but secretly dislike and shun their society. They are reputed to be of a distrustful disposition, and though robust, and capable of enduring great fatigue, excessively indolent. Their habitations are miserable hovels, destitute of every convenience and accommodation, and disgustingly filthy. Their dress is poor and mean; their food coarse and scanty; and their greatest gratification seems to be an excessive indulgence in the use of spirituous liquors. They observe with docility the external rites and ceremonies of the Catholic worship, though it is said they indulge in secret an attachment to the ancient superstitions of their nation.

The language of Peru is still retained by this the greater portion of the inhabitants, who discover so strong an aversion to that of their conquerors, that the clergy and the other Spaniards settled among them learn and commonly use their dialect, with the addition of such Castillian words as signify things not known in Peru at the period of the conquest. The language, called the Quichan, or language of the Incas, is said to be harmonious, and its grammar as variegated and artificial as that of the Greek, though the sounds b, d, f, g, and r, are not to be found in it. A grammar of the tongue has been composed for the instruction of the clergy who are destined to labour in their conversion.

The numbers of the Peruvians had been gradually declining from the period of the conquest till within a few years. The introduction of the small-pox, and the free use of spirits, had a desolating effect; but it is said that their numbers have somewhat increased, especially since the practice of vaccination has been extended to the whole of them.

Productions.

The agricultural productions of Peru are barely sufficient for the subsistence of its inhabitants. In the interior, corn is grown to feed the population; but on the coast, the supply has been in a great measure drawn from Chili. Sugar, cocoa, coffee, rice, maize,

and the various fruits, suffice for the consumption; but there is no surplus, nor any stimulus to produce it, since in all the countries to which the Peruvians can have access the markets can be as well, if not better, supplied from their own soils. Nearly as much wine is produced as is needed, though some is imported from Chili. Oil, brandy, and rum, are made. The former is, however, generally rancid, from the olives being suffered to become too ripe before they are expressed. The spirituous liquors are strong, fiery, and impure, being distilled in the rudest manner. The various kinds of capsicums are cultivated with more attention and skill than any other plants; and, dressed in various ways with garlic, form the most important article of food to the greater portion of the inhabitants. The common beverage is from the leaf of a plant called matte, the tea of Paraguay, an infusion of which, as hot as it can be borne, is drank, or rather sucked through a pipe, by all classes of the inhabitants. As a substitute for drink, the Indians make use of the leaf of a very pungent plant, called coca. A small portion of quicklime is wrapped up in it, and carried in the mouth. The pungent qualities of these two substances excite a most abundant flow of saliva, and serve to allay the thirst of those who travel over the mountains, or the vast plains of sand, where, for days in succession, no water can be obtained. The natives are so much attached to this mode of allaying thirst, and have such confidence in the general salubrious effect of the plant, that they will not commence the labours of mining till they are satisfied that their employers have in store a quantity sufficient for their use.

The demand for animal food is but small, and hence but little attention has been paid to the breeding, and none to the fattening, of cattle. Neither cows nor sheep are numerous: what are found in the country are the progeny of those brought originally from Europe. In the mountainous districts, between Guamanga and Cuzo, both butter and cheese are made; but in the lower country, oil is the universal substitute for the former. Pigs are bred in great numbers in the more hilly districts. The whole coast is well stored with fish of every kind. The natives of the Indian villages on the shore are very dexterous in catching them; and with the addition of capsicum and garlic, they form the chief part of their subsistence.

Mines and Minerals.

The chief riches of Peru have been derived from its mines, especially those of silver. Since the separation of Potosi and La Paz from this viceroyalty, the quantity they have yielded has been gradually diminishing; and, especially since the year 1810, when the civil war with Buenos Ayres and Chili, on one side, and with New Grenada on the other, commenced, the annual produce, both of gold and silver, has most rapidly declined. The mining in Peru has been much injured by the competition of Mexico, where capital is more abundant, where more skill in the operations of extracting and amalgamating is exercised, where provisions, and consequently labour, are cheaper, and where the mines are situated in a much more salubrious climate than those of Peru. Another cause to which the declension of the silver mines may be attributed is the difficulty of procuring mercury; for, having within the viceroyalty, at Guancavelica, mines of that indispensable mineral, too much dependence has been placed on their produce, which is found insufficient for the consumption. Whilst care has been taken to supply Mexico with quicksilver from the mines of Spain and of Istria, the mother country has overlooked their more remote mining possessions on the shores of the Pacific Ocean.

The quantity of gold produced in Peru arises partly from some mines in the province of Tarma, where it is found in veins of quartz traversing primitive rock, and partly from washings established on the banks of the rapid mountain torrents. These last, like the washings in Brazil, have been found to yield less return for the labour employed on them than the common operations of husbandry, and have, in consequence, in many instances, been abandoned. On an average of several years to the year 1800, the produce of silver was 321,165 marks of Castile, each being nearly eight ounces, and of gold 6793 marks. On the average from 1800 to 1810, the silver yielded was 444,229 marks, and the gold 4255 marks. Since that period, the decline is generally asserted to be very great; and from 1810 to 1820, the supply is estimated to fall short by more than one-half of the quantity yielded in the ten preceding years.

Cobalt, antimony, and especially rock salt, abound in Peru; but as they are, except the latter, chiefly found in the mountainous districts, the distance, and the want of roads, render their conveyance too expensive for them to be advantageously carried to any market of consumption. There are a few mines of copper and of lead, which, from the same causes, are worked on a very contracted scale.

Manufactures.

The manufactures of Peru are inconsiderable, and consist chiefly of those homely articles which are required by the poorer classes of the community. On the high land, where warm clothing is necessary, the want is chiefly supplied by a species of long-woolled baize, made from the fleeces of the aboriginal sheep, and in some instances from the wool of sheep of the European breed. In the valleys, and on the coast, where the heat forbids the use of woollens, cotton cloths are made; but of a very inferior texture, from there having yet been no gins introduced, which effectually clear the cotton wool from the seeds of the plant. In dyeing the cloths, whether of woollen or cotton, the natives make use of plants that are scarcely known in Europe, or at least have not been applied to the same purpose. They have a root called reilbon, resembling madder, but with a smaller leaf, an infusion of which dyes a good red. A plant called poquel, a kind of female southernwood, with green checquered leaves, is used for dyeing yellow, as is also the stem for dyeing green, both of which are fast colours. A wild indigo yields them a blue dye, and the panque a good black. The dress of the natives is very simple; consisting of a square cloth, with a hole in the centre, through which the head is thrust, and which falls before and behind so as to defend the whole body. The head is generally covered with a hat made of the straw of the maize, which is as large as, and serves the purpose of, an umbrella.

The commerce of Peru, as may be seen by the small surplus of its productions, is very inconsider-

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able. With the province of Buenos Ayres a trade was carried on by exchanging for the matte or tea of Paraguay, coined dollars, some brandy, and a few of the coarse woollens made in Cuzo. By the same channel some few European goods arrived, as well as the small number of negro slaves that were needed for domestic servants, in which capacity they are chiefly employed. By sea, a trade was carried on with Chili, which consisted in exchanging the wheat, wine, and copper of that country, for sugar, coffee, cotton, and silver. A vessel or two arrived from Manilla with the productions of the East Indies, for which silver only was paid. The luxuries for the few of the richer class were drawn chiefly direct from Spain, or by a contraband intercourse with English or North American traders. The annual imports from Spain, on an average of years, amounted to 4,180,000 dollars; of which about 1,950,000 consisted of Spanish, and 2,230,000 of foreign productions. The annual exports from Peru, in the same period, consisted of money, silver, and gold, amounting to 4,962,700 dollars, and other commodities amounting only to 726,800. The chief exports of goods were Peruvian bark and cocoa, the latter of which had been previously imported from Guyaquil. The ships from Europe that have sailed to the ports of Peru have found no productions there which would pay any return freight; and they have almost uniformly, after discharging their outward cargoes, proceeded to the port of Guyaquil, where a return cargo of cocoa could be generally obtained on such moderate terms as to pay a profit in Spain, where the demand for that commodity is very extensive.

Navigation.

The Pacific Ocean is by no means favourable to commerce. On the whole extent of coast in Peru there is no harbour except that of Callao, the port of Lima, which can be entered by a vessel of such a size as is fit for the navigation from Europe round Cape Horn. As the wind constantly blows from the southward, varying only as the coast trends, whereever there is a high projecting headland there is shelter, and sometimes good anchorage to the northward of it; as at Ylo, Iqueque, and some other parts. On every part of the shore, the uninterrupted swell from the sea causes such a tremendous surf on the beach, that no communication can be had with the shore, by any such boats as are carried by European ships. The natives have long ago contrived a means of passing this surf, on what is called a *Balsa,* whose buoyancy is such as to carry them over the most terrific breakers in perfect security. It is constructed of two skins of the largest sized seals, which are inflated and lashed side by side. On a small platform fixed on them, the native sits, with a pipe made of the entrails of the seal, communicating to each of the inflated skins, with which he fills them by his breath, as frequently as the evaporation of the wind makes it necessary. On these contrivances, which resemble two enormous bladders, the natives fear no waves or breakers, and frequently proceed to such a distance as to lose sight of land. By the assistance of a paddle, and occasionally of a small sail, these vessels become perfectly manageable at sea, and they have the advantage of being easily carried to their own habitations when not employed on the ocean.

A species of vessels, called by the same name, is used for longer voyages. These consist of an unequal number of trees of light wood, merely squared, and securely lashed together, but so loosely as to admit the action of the waves between them, like the catamarans at Madras. The centre tree is longer than the others, and serves the purpose of a prow. These vessels, some of which are more than 100 feet in length, have huts constructed upon them for the crew, and pass with security from the shores of Peru to the ports of Guyaquil and Panama. The deficiency of stores for naval equipment on the shores of the Pacific is such, that substitutes are used, which alarm a European sailor till he becomes familiar with the smooth surface and uniform winds that prevail on that sea. Instead of water casks, jars are fastened in the hold to contain that necessary element. The rigging is made of white rope, as the only tar they have burns the hemp, and is only fit to be applied to the bottoms of ships. The sails are made of narrow strips of cotton cloth, very clumsily fastened together. With such equipment, however, they make secure voyages; but not with much celerity when proceeding to the north, and with a most protracted delay when, on returning to the south, they are under the necessity of tacking.

Revenues and Forces.

Although, in the present unsettled state of Peru, the amount of its revenues, and the armed force which it maintained, become matters of but little importance, yet it may be noticed, that, under the colonial government of Spain, the revenues of the crown amounted *communibus annis* to about 6,000,000 dollars, and the expenditure to about 3,200,000; the balance was annually remitted to the parent state. The armed force consisted of the regulars, who were 2200, including 280 cavalry and 40 artillery. The disciplined militia were 8000 infantry, 2280 cavalry, and 490 artillery. Besides these there were 85 regiments, known as provincial militia, amounting to 21,700 men; but these had no arms, were rarely mustered, and then exercised only with sticks instead of muskets, and were of little use except as the means of gratifying the vanity of the natives by conferring on them the military titles of colonels, majors, captains, &c., as is said, to the great emolument of the Viceroy and the officers of his establishment.

Intendancy of Lima.

The intendancy of Lima is chiefly remarkable for containing within its limits the capital of the viceroyalty, from which it derives its name, and the excellent port of Callao, the chief mart for the commerce of Peru. The capital is situated in latitude 12° 2′ 25″ south, and in longitude 77° 7′ 15″ west from Greenwich. The inhabitants amounted to about 54,000, of whom 19,000 are proprietors of estates or mines, clergy, lawyers, physicians, civil and military officers, and various traders; the remainder are slaves, domestics, or labourers. The city is surrounded with walls, but they scarcely merit the name of fortifications. The buildings are spacious but low, having but one story; they are built of wooden frame work, interlaced with canes, plastered over with clay, and painted to imitate stone. This

mode of building prevails, from the frequency of earthquakes, whose force, such erections are more capable of bearing than solid buildings of stone or brick. It is supplied with fresh water by a rapid stream that passes through it, which is received into reservoirs and fountains in various parts of the city. The Viceroy's palace, the cathedral, the town-house, and archiepiscopal palace, form a square, and are said to be magnificent piles. In former times, the entrance of a new Viceroy was celebrated by a display of ingots of silver, with which one of the streets was completely paved; and the quantities of the precious metals displayed in the churches, and in their religious processions, are said to have exceeded what was to be seen in any of the Catholic countries of Europe. The country immediately around the city, being well irrigated, is fruitful in tropical productions; the sea supplies abundance of fish, and, as the elevated mountains approach near to it, the varieties of climate which their different elevations create, allow of cultivating most of the plants of the temperate zone, and of producing good meat and poultry.

Lima is the seat of the Royal *Audiencia*, or Chief Court of Justice. It is the see of an archbishop, whose income was 30,000 dollars, and who has four bishops under his superintendence within the viceroyalty, viz. Traxillo, Gumanga, Cuzco, and Arequipa, and four others, within the limits of New Granada, viz. Panama, Quito, Maynas, and Quenca.

Callao, formerly called Bellavista, is the port of Lima, and, as has been before mentioned, the only good harbour in Peru. It is defended from the winds, which blow always from the south, by the Island of St Lawrence; to the north of which, in smooth water, is good anchorage, under the protection of the guns of the strong forts. The depth of water is sufficient for the largest ships; the means of loading and discharging them are easy; and as the river Rimac empties itself into the sea at this place, the shipping easily obtain a supply of fresh water. As there is but little rise of tide, there are no docks; and vessels that need repair can only be careened. It is in south latitude 12° 3′ 42″, and west longitude from Greenwich 77° 14′.

The other towns are Guara, Chancay, Canete, Ica, Pisco, and Nasca, none of which, except Ica, contain more than 1500 inhabitants, of all descriptions. There are few mines in the intendancy of Lima that are worked; the chief is that of Conchapatu, in the mountains of Guarachiri, which yields some silver, and which would also, if the roads would allow of it, supply the capital with coals. Antimony and cobalt are likewise to be found in the same district.

The intendancy of Cuzco lies on both sides of the Andes, and partakes of that great variety of climates which is produced by the different elevations and aspects of that prodigious range of mountains. Though the cold is so intense as to forbid human residences on the summits, or cordilleras, yet the chief places which are inhabited enjoy a mild and temperate climate. It is bounded on the north by the great river Apurimac, on the east by unreclaimed countries, on the west by the provinces of Tarma, Guancavelica, and Gumanga, and on the south by Arequipa and the viceroyalty of La Plata. This is the chief seat of what manufactures of woollens and of leather exist in Peru; as both sheep and cows are here more abundant than in any other part of it. The district of Cannas is celebrated for breeding mules; of which animals more than 30,000 are annually sent to the towns on the coast. The agricultural productions generally partake rather of the character of those of the temperate than the torrid zone; wheat, barley, and other European grains, forming the chief articles of cultivation. There are many silver mines, and some few washing places for gold. The principal of the former are at Carahuasi, near the capital, in the district of Cotabamba, in Condonoma, Aymaraez, and especially in the province of Lampa.

Intendancy of Cuzco.

The chief city of the intendancy, Cuzco, was the seat of the Peruvian monarchy when visited first by Europeans, and the situation of it, as well as its climate, were well chosen. It is in south latitude 13° 25′, and west longitude 71° 15′. It is surrounded by the mountains of Sanca on its north and west sides, and has a beautiful plain to the south, through which the river Guatanay, which passes the city, runs. On the mountain to the north of the city are the remains of the fortress of the Incas, intended to be rendered impregnable by the height of the wall, and the steepness of the passes which it was designed to defend. The internal works are in ruins, but a great part of the wall is still standing. Some of the stones prepared for this work are of such a size, as to create wonder in what manner they could have been moved by people so unacquainted with powerful machinery, as the Peruvians certainly were. Though the palace of the Incas has been destroyed, yet a subterraneous passage, communicating between it and the fortress, may still be traced. Cuzco is at this time a large city, containing 32,000 inhabitants, three-fourths of whom are Indians, who are industriously employed in the manufactures of woollen baize, of cotton, and of leather. The number of Spanish families is small, and they have of late declined as compared with the Indians and Mustees. It is the see of a bishop, whose revenues amounted to 20,000 dollars, of a Royal Audiencia, a mint, a university, and of a college, specially appropriated for the education of the children of the Caziques. The cathedral is a noble pile of building, of stone, and there are also six parish churches, nine convents, and four nunneries. The church belonging to the Dominican Convent stands on the identical spot which was formerly covered by the Temple of the Sun, and is built of the stones which composed that edifice. The high altar fills the place in which once was fixed the image of that luminary which was the object of worship to the idolatrous aborigines. The dwellings of private individuals are substantially built of stone, and if not furnished with much attention to comfort, are decorated in a costly manner. The other towns are very small, as most of the inhabitants lead a rural life, occupied in cultivation and in breeding cattle. The chief of those towns are Abancay, Urcos, Calca, Cotabambas, Tinta, and Lampa, none of which contain so many as 1500 inhabitants. The difficulty of communication between these places is such as to forbid much intercourse. The rapid streams descending from the Andes have worn such

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numerous and such deep ravines, as are only to be crossed, with great risk, by bridges of ropes; and frequently are passed by suspending the travellers in large baskets from cables stretched across fissures, along which they descend from the higher to the lower banks of the tremendous precipices.

Intendancy of Arequipa.

Arequipa is an intendancy stretching along the borders of the Pacific, but extending sufficiently inwards to contain a large mountainous district within its limits. Its southern boundary is the inhospitable desert of Atacama, the passage over which to Chili has proved fatal to many travellers. Few of the provinces of South America contain within them a greater portion of vegetable and mineral wealth than Arequipa. Its plantations yield maize, sugar, and coffee. The vineyards are extensive, especially those of Moquehua, which produce a delicious red wine, and the brandy distilled in this district supplies an extensive circle of the mountainous countries. The most celebrated of the silver mines are situated on the southern part of this intendancy; those of Huantajaya, near the small port of Yquique, are surrounded with vast beds of rock salt, in a district totally destitute of water, and where provisions are scarce, but as the silver is found in native masses, it has produced usually about 100,000 marks annually. The district of Caylloma contains several mines of silver, but they are very imperfectly worked. They are in a very high elevation, and consequently in a climate most intensely cold. The surrounding country produces but few means of subsisting the labourers; and though there is an office for distributing quicksilver to the miners, the situation has proved an impediment to successful operations, and the expence has equalled, and, in some instances, exceeded the amount of the metal that has been produced.

In Condesuyos are mines both of gold and silver, though slightly worked; as many of the inhabitants have found more profitable labour than mining, by raising silk-worms, and by breeding the cochineal insect.

The city of Arequipa, the capital of this intendancy, is situated in the beautiful valley of Quilca, about 60 miles due east from the port of Atranta. It is in 16° 16′ of south latitude, and 71° 58′ west longitude. The buildings are substantially constructed of stone. The public edifices are a cathedral, six convents, a college, a hospital, and revenue office. It is well watered by the river Chile, which serves extensively the purpose of irrigating the surrounding lands. The climate is healthy, and though frosts are sometimes experienced in the night, they disappear as soon as the sun rises. The inhabitants amount to about 24,000, one-third of which are said to be Spaniards. This city has been repeatedly laid waste by earthquakes, and once by an eruption of the volcano Guayna-Patina, which is in its immediate vicinity. The other towns of most consideration are Camana, Ocana, a small bad port, Caylloma, Moquehua, Arica, and Tacna, none of which are either populous or rich, and are chiefly inhabited by Indians.

Intendancy of Truxillo.

The intendancy of Truxillo is the most northern, as well as the most extensive, division of Peru. It is chiefly remarkable for being the first port in which Pizarro and his followers landed. The face of the greater part of the district has all the predominant features of the Arabian desert. From Tumbez, the boundary, to the capital of its department, Piura, a distance of more than 200 miles, there is but one small Indian village. No water is to be found in any other place, and that indispensable article must be conveyed in skins, on mules, for the use of travellers. In this sandy desert, the most experienced guides sometimes lose their way, and the bodies of passengers are occasionally buried under the waves of shifting sand. There are, however, some spots within the intendancy that enjoy a high degree of fertility; of this description is the district of Caxamarca, situated between two ridges of the Andes. Corn of all kinds, various fruits, and esculent vegetables, are abundantly produced, as well as cows, sheep, and hogs, in the latter of which, salted, a considerable trade is carried on with the warmer districts. At this place are the remains of the ancient Palace of Atahualpa, from whence Pizarro directed his operations, and where that monarch was killed. It is situated on the western declivity of the Andes, about 9000 feet above the level of the sea, 70 miles from the Pacific Ocean, in latitude 8° south, and longitude 76° 10′ west from Greenwich. A family descended from the Incas, reduced to a state of comparative indigence, occupies this ancient residence of their royal ancestors. In the vicinity of Piura, and around the city of Truxillo, the tropical productions, sugar, coffee, and cotton, are cultivated; there are also some vineyards which afford wine and brandy.

The chief mines within the intendancy are those of Chota, near the limit of perpetual snow, being 13,800 feet above the level of the sea; of Micuipampa, 12,000 feet; and some at Pataz which yield both gold and silver.

There are two cities in the intendancy. Truxillo, the capital, is the sec of a bishop, and the seat of the courts of justice. The inhabitants are about 6000, principally rich Spaniards, who indulge in considerable show and luxury. Piura contains about 7000 inhabitants, chiefly Indians. The other towns, Tumbez, Lechura, Payta, Lambayeque, scarcely contain 1000 inhabitants each, who are in a low state of indigence.

Intendancy of Guamanga.

Guamanga, or Huamanga, is an intendancy wholly internal, surrounded by other parts of Peru. From its elevation on the sides of the Andes, it enjoys a mild and temperate climate. It is much intersected with streams, or rather torrents, which have worn deep chasms in the friable soil, and prevent easy communication between its several districts. It yields excellent corn and fruits, and the wool of the sheep is here made into baize for clothing the inhabitants of the colder districts. In the mountains are found herds of huanucos, or Peruvian camels, employed as beasts of burden in the colder regions, and whose wool is used in the manufactories. There are also many cows and sheep of the European breeds, reared within the district. It is the chief country for the growth of the coca, which serves to the natives of Peru the same purpose as the betel does to those of the East Indies. There are mines of lead, gold, and silver; but their working has declined of late years, so that the supplies from them are dwindled to very insig-

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nificant quantities. The capital, Guamanga, situated in south latitude 12° 50′, and west longitude 77° 56′, is a well built city, of considerable extent. Its population amounts to about 26,000, of whom the greater part are Indians. It is the see of a bishop, contains a cathedral, a university, well endowed, and several churches and convents. There is no other place in the intendancy meriting the name of a town, as three-fourths of the inhabitants are either occupied in cultivation or in pasturage.

Intendancy of Guancavelica.

The whole of the intendancy of Guancavelica, or, as it is sometimes spelt, Huancavelica, is situated in the mountains in a climate severely cold, which may account for the paucity of its population. The chief value of this intendancy is derived from the important mines of quicksilver which it contains, and which, if properly conducted, would make the mines of silver in Peru equal in their product to those of Mexico. The celebrated mine of Santa Barbara is 13,800 feet above the level of the sea. In the process of excavating it, three stories of galleries, one over the other, have been constructed, which penetrate the mountain in different directions, according as the veins of the mineral are found to run. The lowest of these was found to contain red and yellow sulphureted arsenic, which, proving fatal to many of the labourers, was forbidden to be worked. The chief produce of the mine has been obtained in the form of cinnabar, from which, by distillation, the mercury is extracted at the rate of one pound of mercury from every fifty pounds of cinnabar. The upper of the three stories, called the *brocal*, furnished by far the largest part. This branch, however, has been nearly destroyed, either from the negligence or the avidity of the managers. The roof of the mine was supported by pillars, left at intervals, which consisted of the ore. As the ore became rather scarce in the interior of the mine, these pillars were gradually thinned away till they became incapable of sustaining the weight that rested on them; they gave way at length to such an extent as to fill the mine with masses of the superincumbent rubbish, which has intercepted all communication with the interior. Some ineffectual attempts have been made to remove the impediments, but the silver mines are chiefly supplied with their mercury from small veins in the same chain of mountains, which yield an insufficient quantity, and at a dear rate. The capital, which gives name to the intendancy, is in south latitude 12° 45′, and west longitude 74° 46′. It was, when the mine was actively worked, a populous place, but at present contains only 5000 inhabitants. It is built almost wholly of tufa, which is found in abundance in its vicinity. The surrounding country is highly picturesque, abounding in torrents and cascades; but the climate is prejudicial to the human constitution, from the great and sudden changes of the temperature. There are scarcely any places that deserve to be called towns; as the few inhabitants are scattered at great distances from each other in thinly peopled villages or hamlets.

Intendancy of Tarma.

The intendancy of Tarma is chiefly situated on the Andes, and generally partakes of the severity of climates which lofty elevation creates. The small portion of it which is on the plain yields wine, but the great portion of the inhabitants are supplied with animal and vegetable food from the mountainous regions, which, at a moderate height, produce corn and potatoes, and at a greater elevation breed considerable flocks and herds. The mines most productive of silver are within this intendancy. The most eminent are those of Lauricocha, or, more properly called, collectively, the Mines of Pasco. Nearly one-half of the silver which Peru yields is extracted from these mines. They are at an elevation of 13,000 feet above the sea. The veins of the mineral are near the surface, the shafts being only from 90 to 400 feet in depth; below that water is found, the expence of clearing which is the chief drawback from the profit of the proprietors. The metalliferous bed is stated to be more than 15,000 feet in length, and upwards of 7000 in breadth, and is capable of yielding more silver than any even of the mines of Mexico.

The favourable circumstances attending these mines, and the belief, that, if the water could be cleared by a steam-engine, the profits would be immense, induced a party of Englishmen to convey a powerful engine to the spot. After many interruptions and much delay, it at last reached these mines; but the country was in too turbulent a state to admit of the operations being carried on; which, with the unpopularity attached to the undertaking, from supposing it would lessen the employment of labourers, has caused it to miscarry, and the water has so gained, that the produce has declined very much since the commencement of the civil wars. There are many other mines in different parts of this intendancy, of which the greater part are neglected, or very feebly worked. The greatest portion of the gold found in Peru is taken from the mines of Pataz and of Huilies in this province. Tarma, the city which gives its name to the intendancy, is in 11° 35′ south latitude, and 75° 17′ west longitude. It contains about 5500 inhabitants, some of whom find employment in making baize. No other place contains as many as 1000 people.

Recent History of Peru.

No country, perhaps, ever enjoyed so long a period of freedom from hostilities as Peru has experienced. Though occasionally, when at war with England, a few places on the coast have suffered from predatory attempts, and the navigation may have been interrupted by our cruizers, yet, in the interior, tranquillity has been undisturbed during the whole period that elapsed between the suppression of the revolt of Gonzales, by Pedro de la Gasca, in 1548, till the year 1781, when an Indian insurrection of a most alarming kind suddenly burst forth.

Jose Gabriel Condercanqui was a descendant of the last sovereign of the Peruvian race. He had been carefully educated by his father, and exhibited considerable talent. The title of Marquis of Oropesa had been conferred on one of his ancestors. On the death of his father, he petitioned to have that title renewed in him, but being refused, he retired to the mountains, and announced himself by the name of Tupac Amaru, which the last of the Incas had borne, as the true sovereign of Peru. The Indians flocked to him in crowds, the sacred fillet was bound on his brow, and he was proclaimed emperor, by the title of Tupac Amaru the Second. An overwhelming army was speedily collected by him, which subdued the country and invested Cuzco. At the com-

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mencement of his reign, though he declared vengeance against every native of Old Spain, he professed to favour equally the ecclesiastics, and all of the white race who were born in America. Adhering to this system, he continued to prosper, but his followers, elated with the success that everywhere attended them, and being in an undisciplined state, commenced a war of extermination against all who were not of the Peruvian race; which was attended with scenes of the most horrid barbarity. Diego his brother, and Andres his nephew, favoured the cruel disposition of the Indians, and perpetrated deeds which Jose Gabriel vainly strove to prevent. The insurrection continued two years, and extended over most of the districts around Cuzco; but the proceedings against the Whites, Mustees, Mulattoes, and Negros, at length united these casts against the Indians. Jose was surprised, and, with his family, taken prisoner; and shortly after, the whole were executed in the city of Cuzco. So great was the veneration in which this Tupac Amaru was held by the Peruvians, that, when he was led to execution, they prostrated themselves in the streets, and uttered the most piercing shrieks and execrations, whilst the last of the Children of the Sun was torn to pieces by his executioners. With this event terminated the struggles of the Peruvians for independence; and on late occasions they are reported to have shown more disposition to adhere to the government of Spain than to the newly created independent states that have sprung up around them.

Wars with New Granada.

During the period in which the surrounding dominions of Spain in South America were torn by intestine wars, Peru, though engaged in hostilities, has not been the theatre in which the contest was conducted. Allegiance to Spain was maintained through all her changes of government, and the Viceroy of Peru continued to exert himself to subdue the other countries that had revolted from it. When the revolution in New Granada began, the first steps were such as threatened no disturbance to the neighbouring provinces; but its spirit at length approaching the confines of Peru, the Viceroy dispatched an army towards Quito, under the command of General Molina, who had been nominated President by the Junta of Cadiz. As the revolutionists were divided among themselves, he easily gained that city; but practising some most cruel measures, according to the accounts of the insurgents, and we have no other, the army was compelled to retreat before the different partisans, who were previously at variance, but who had united in their operations against the Peruvians. After a bloody contest, they were driven from the viceroyalty of New Granada by the republican general Marino; but as his attention was strongly engaged in watching the events in the north, he could not follow up his victory by pursuing the royalists; who, on their part, had such calls for their exertions towards the frontiers of Buenos Ayres, and in Chili, that, without any formal treaty, hostilities ceased between Peru and New Granada in 1814, and have not been since renewed.

Wars with Buenos Ayres.

As soon as the inhabitants of Buenos Ayres had formed an independent government, an army of 5000 men was marched to invade Peru, under the command of General Balcarce. He was opposed before he had reached the frontiers by Goyneche, a royalist commander. Before hostilities were begun, a treaty for an armistice was made, but soon broken, when the Peruvians repulsed their invaders, became invaders in their turn, and overrun the country as far as Salta; having in their possession, in 1812, the rich mining countries of Potosi and La Paz; while the republicans, being embroiled among themselves, and invaded by the Portuguese, had no means of recruiting, till early in the year 1813, when their general Belgrano attacked the royalists near Salta, and gained a complete victory, which compelled them to abandon their conquests, and retire within their own territory. In November of the same year, the Peruvians, being reinforced, fought another battle on the frontiers, near Potosi, with such decided success, that they again occupied those rich districts, which, in the early part of the year, they had been compelled to abandon. The unfortunate republican general Belgrano was, in 1814, superseded by the celebrated San Martin, who collected the fugitives, organized a new army, formed various corps of Guerillas, and compelled the royalist general Pezuela once more to retreat from the contested country, and concentrate his forces in High Peru. In the year 1815, the contests among the different parties of republicans having weakened their army on the frontiers, Pezuela again attacked them, on the 14th November; gained a hard-fought battle at Sipe-sipe; and, in consequence of it, the mining districts of Buenos Ayres, for the third time, came into the hands of the royalists. The calls on the Viceroy of Peru for troops to maintain the royal cause in Chili weakened his frontier forces at the time that San Martin was collecting his army to invade that country on the part of the republicans. By the course of events, the theatre of the war thus became changed. The republicans kept up a small force to watch the motions of the royalists, whose troops and stores were so much diminished, that they ultimately withdrew from the conquered countries; which, by the operations of the remorseless contest, had become reduced to the extreme of misery, and the mines, once so highly productive, had nearly ceased to be worked.

Wars with Chili.

Chili had thrown off the government of Spain, and declared its independence. It was torn by factions, violently irritated against each other, and a civil war had commenced. The Viceroy of Peru thought the occasion favourable for bringing it again under the royal authority. A force of 4000 men, under General Paneja, was dispatched to that country. He landed at Talcahuano early in the year 1813, and took possession of Conception and Chillan. The Spanish troops appear to have remained in the positions they occupied, in a state of great inactivity; whilst the Chilians, divided into rancorous factions, were exhausting their means, and impoverishing their country. The Spanish commander availed himself of the circumstances to make an attempt on the capital, in the beginning of March 1814; but, not succeeding, entered into a treaty for evacuating the country. Before the treaty was concluded, General Osorio arrived, as commander from Lima, with considerable reinforcements. This changed the face of affairs. The Chilians were wearied with the evils they had experienced; the forces of the King gave them confidence;

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and after a few skirmishes, rather than battles, with the different parties, who never ceased hostilities towards each other, the whole country submitted to Osorio, who entered the capital in October 1814. The royalists were in quiet possession of Chili till the beginning of the year 1817. The fugitive republicans had retreated over the Andes, and found an asylum in Mendoza. There others joined them, in the following years. The government of Buenos Ayres supplied them with stores, and at length General San Martin, with the addition of some tolerably disciplined troops, was appointed to the command. This force passed the Cordilleras in January 1817, and descended towards the level country; and, after a most complete victory over the Peruvian army at Chacabuco, in which their commander was made a prisoner, and his troops dispersed, occupied, with little difficulty, the whole of Chili. The government there having assumed a more consistent and regular form than before, became a collecting point to which adventurous spirits, from Europe and from America, resorted. Armaments were equipped there, both naval and military. The former were successful in making prizes, and, in combination with the latter, Valdivia, the only remaining fortress in Chili, under the command of the Viceroy of Peru, and ultimately Lima itself was captured.

Expedition of Lord Cochrane and San Martin.

The conquest of Peru seemed to be indispensably necessary to the preservation of that independence, and those republican institutions which the inhabitants of Chili had established. It had early attracted their regards, and the project for achieving it, which was widely circulated, drew to them many of those military adventurers who, by the peace in Europe, were deprived of occupation. Among others, Lord Cochrane and several English officers who had distinguished themselves in the naval service, found employment in the fleet which was speedily equipped, and which, in discipline, though not in force, soon attained such a superiority over the navy of Spain as to give it the command of the navigation of the South Sea. Being to windward of the Spanish ports, it was easy at any time to choose the point of attack. An army of 5600 men was formed, under San Martin, which, with the fleet, consisting of one ship of 64 guns, one of 50, one of 36, and one of 32, besides some corvettes and transports, sailed from Valparyso, in the latter end of 1820, and reached Lima in February of the following year. The troops were landed to the north of Callao, and continued, without any great exertion, till May, when the garrison of Lima being much straitened, an armistice was concluded.

Pezuela, then the Viceroy of Lima, was opposed by the Audiencia and the Municipality, who censured him for not adopting measures sufficiently energetic to repel the invaders. The same disposition to censure prevailed among the officers of the army; and at length they resolved to depose Pezuela. He made no resistance, but quitting the government and country, the command was placed in the hands of Don Jose de La Serna on the 29th January 1821.

The troops of La Serna were not much superior to the invaders numerically, but some of them having gone over to San Martin, gave the latter a superiority. Lima continued to be straitened by the general, and Callao to be blockaded by Lord Cochrane, who performed one of those acts of desperate valour which struck astonishment into the Spaniards. With the boats of his little squadron he entered the port of Callao, and, under the guns of its tremendous batteries, boarded, captured, and carried off one of their largest ships of war, with more men on board than were in all the boats that attacked her.

Surrender of Lima.

After some months had elapsed, a convention was agreed on, when La Serna with his army marched out, and San Martin with his forces entered Lima. A garrison was, however, left by the royalists in Callao. The protracted operations had given time to remove the most valuable property, which, with the females of the best families, and the non-combatants, reached the mountainous districts. San Martin, in the possession of Lima, was in the same condition as La Serna had been for some months before; with many mouths besides those of his army to fill, and his intercourse with the country that furnished provisions intercepted; but he had the advantage of naval superiority, and could draw supplies from the coast, though, till Callao was taken, the difficulty of landing made the arrival of such supplies precarious. At length the garrison of Callao agreed to evacuate, on being allowed to join La Serna, which was effected. San Martin was thus in full possession of the capital and its port, when a dispute between him and Lord Cochrane, about the division of the insignificant plunder, caused the latter to sail to some unascertained destination, and leave the commander of the land forces to secure his conquest. He there assumed the sovereignty, and acted the part of an absolute monarch, uniting in himself the legislative, judicial, and military power.

La Serna, after uniting with the garrison of Callao, retired towards the mountains, where he intercepted all communication between Lima and the mining districts, and drew supplies of men and stores from the countries in his rear. The whole of the treasure captured in Lima did not exceed 300,000 dollars, not a tenth part of what was usually to be found in that city. Cochrane having carried away the money, his coadjutor was soon compelled to have recourse to violent measures to subsist his army. He stamped paper dollars to pay his troops, and issued decrees commanding the inhabitants to take them in payment. A civil war is thus existing, which, as far as the latest intelligence reaches, leaves it doubtful if the conquerors or the conquered are in the worst condition. Whatever may be the ultimate issue, it must probably be a long time before tranquillity can be restored, to such a degree as to give that security to property which is more essential to mining than to any other of the operations of human industry. In whatever manner the present contest may terminate, it is not possible to conceive, that in future Peru, or any part of South America, will be subjected to the condition of a Spanish colony.

See Helm's *Journey through Peru, from Buenos Ayres to Lima*; *El Viagero Universal*, por Estalla; Feyjoo *Relacion de la Cuidad de Truxillo*; *Mercurio Peruiana*, and *Guia de Peru*, por Hipolito Unania; Humboldt's *Works*; and Bonnycastle's *Spanish America*. (WW.)

PHYSICAL GEOGRAPHY.

Physical Geography.

THE object of Physical Geography is to describe the external structure, form, and appearance of the globe, and the relations subsisting between it and the various classes of animated and organic beings which inhabit its surface. It ought to comprehend a description of the solid parts of the globe, with their magnitude, position, and the progressive changes they have undergone,—of the fluid parts, consisting of seas, lakes, and rivers, with their extent, motions, and general physical qualities,—of the atmosphere, with the phenomena it presents, including the variety of climates and seasons in different regions. Lastly, it should embrace a general view of the various tribes of animals and vegetables, with the order of their geographical distribution, in the ocean, the atmosphere, or on the land. Physical geography has but recently begun to assume the form of a science, and, like other branches of knowledge depending on extensive and multiplied observations, it can only be improved by slow degrees. To render it perfect, it would be necessary that we should know the true geographical position of every point of the earth's surface, its height above the sea, its mean temperature for every month, the prevailing winds, the annual and monthly depth of rain, the rate of evaporation, the nature of the rocks, the heat of springs, the peculiarities of the soil, with the animals and vegetables which can find nourishment upon it, and are adapted to the climate. We should know also for each part of the ocean, its depth, temperature, general and particular motions, and other physical properties, with its peculiar vegetable productions, and classes of living inhabitants. And to raise this knowledge to the rank of philosophy, effects should be traced to their causes, and the infinite variety of phenomena connected by a small number of general principles, by the help of which we might be able, from the knowledge of a few facts, to form certain conclusions respecting a multitude of others. Though physical geography is still far from this degree of perfection, writers upon the science have already collected, and to some extent generalised, a great number of interesting facts. To exhibit a systematic view of these is our object in the following pages; but we think it necessary to state, that we must necessarily confine ourselves within limits which will preclude extensive details upon any part of the subject.

Magnitude. The earth is one of eleven spherical bodies, denominated planets, which revolve round the sun. Its distance from that luminary is 93,595,000 English miles, and its mean diameter is 7912. It completes its diurnal revolution in twenty-four hours, and its annual revolution in $365^{d}.\ 5^{h}.\ 48'\ 51''$. One satellite, or attendant body, the moon, 2180 miles in diameter, revolves round the earth in $29^{d}.\ 12^{h}.\ 44'$, at a mean distance of 475,000 English miles. The relations of these bodies to the sun and the other planets, and the laws which regulate their motions, belong properly to astronomy. (Playfair's *Outlines of Nat. Phil.* II. 86, 125, 126, 225.)

Form. The earth is not a perfect sphere in its form, but an oblate spheroid, or sphere flattened at the poles. The amount of this compression is such, that the equatorial diameter exceeds the polar diameter, or axis, by twenty-five miles; or the one is to the other as 312 to 311. The centrifugal force arising from the revolution of the earth round its axis, which evidently tends to dilate the equatorial parts, led Newton to infer the oblate or compressed figure of the globe before it was known by experiment. He calculated the ellipticity, from theory, at $\frac{1}{230}$, which is about one-third greater than the truth. A homogeneous fluid body of the mean density of the earth, and making its diurnal revolution in the same time, would, in fact, have the proportions which Newton supposed; and the ellipticity in this case would be a maximum. But if the revolving body, instead of being homogeneous, increase in density towards the centre, the compression is not so great. Now, the experiments made at Schehallien show that the mean density of the earth is nearly double of that of the rocks at its surface, and, of course, the density of the central parts must be still higher than the mean. Mathematicians have demonstrated, that, were the density to increase so as to be infinitely great at the centre, the ellipticity, in that case a minimum, would be no more than $\frac{1}{578}$. The structure of the globe as to density, so far as our knowledge extends, is intermediate between these extreme conditions; and since its ellipticity of $\frac{1}{312}$ is also intermediate between the maximum and minimum, the circumstance affords a strong presumption that its form approaches very nearly to that of a spheroid of equilibrium, and in all probability coincides with it entirely. (Playfair's *Outlines*, II. 60, 302, 304.)

This conclusion is strikingly confirmed by the phenomena presented by those planets, in which the supposed cause of the ellipticity exists in the greatest degree, Jupiter and Saturn. As each of these bodies has a diameter ten times greater than that of the earth, and revolves round its axis in less than half the time, the centrifugal force ought to be far more powerful, and produce a much greater dilatation of the equatorial parts. Accordingly, in Jupiter, the ellipticity is one-fourteenth of the longer diameter, and, in Saturn, where the effect of the centrifugal force is aided by the attraction of the ring, the ellipticity amounts to one-eleventh. (Playfair's *Out.* II. 179.)

We have good reason to conclude, that whatever causes gave this oblate figure to the globe, they have acted upon the solid as well as the fluid parts. Though the land and water are unequally distributed over the two hemispheres, the soil, in a general point of view, is as much elevated at the equator as towards the poles. But since the equatorial regions are about

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twelve miles farther from the centre than the parts at the pole, it is evident, that, had the sea only been subject to the action of the centrifugal force, the torrid zone must have been completely submerged, and the polar regions left entirely dry, and rising many miles above the level of the waters. The ocean must, in fact, have formed a broad and deep zone round the equator, separating the two continents encircling the poles; of which continents a very small part only would have been habitable in consequence of the elevation of the soil. The figure of the globe affords, therefore, evidence of considerable weight in favour of its original fluidity, and it negatives the idea, that the earth, at the period of its consolidation, had a different axis from what it has at present.

Density.

The precession of the equinoxes, and the nutation of the earth's axis, indicate, in the opinion of Laplace, that the density of the globe increases towards the centre. Mr Cavendish, from some experiments with leaden balls, estimated the mean density of the earth at 5,48. (*Phil. Trans.* Vol. LXXXVIII. 469.) But the calculation most to be depended on is that founded on the experiments at Schehallien, which gives the mean density equal to 4,71 (Playfair's *Out.* II. 320), that is, about $4\frac{3}{4}$ times the weight of an equal bulk of water. As the density of the rocks at the surface, which does not exceed 2,5 or 2,7, is much lower than the mean, it follows, that the density of the central parts must be much higher. If, for instance, the exterior rocks with which we are acquainted should form a shell of 500 miles in thickness, the parts within this shell would require to have an average specific gravity of 5,8 to produce the mean density of 4,7 for the whole mass. Laplace thinks, however, that the change in density is not sudden but progressive, and that it is probably the effect of concentric and elliptical beds, of increasing density, disposed symmetrically round the centre of gravity. (Daubuisson, *Traité de Geognosie*, Chap. I.) This disposition would naturally take place in a mass simultaneously fluid. And, in fact, the lowest rocks with which we are acquainted have generally a greater specific gravity than those which lie above them. The only considerable class of mineral substances known to us, which have the high density inferred to exist in the central parts of the globe, are the metals and their ores. This circumstance may, perhaps, authorize a conjecture, that these substances occupy the interior of the earth, and that the metallic repositories found in the outer crust consist of minute portions, separated and cast up from the central mass.

Geological Structure.

It would be foreign to our purpose to enter into the disputes which divide geologists. Conceiving that the principles of geology, at the present day, are to be considered as little better than provisional, we shall recur to them as sparingly as possible. Of the central nucleus, as already stated, we can know nothing but by inference. The outer crust, however, lies exposed, in part, to our view, and the materials of which it is formed, so far as we are acquainted with them, consist of *four* great classes. 1. Those rocks which neither contain any animal nor vegetable remains themselves, nor are intermixed with rocks which do contain them, and are therefore termed primitive, or *primary*, as having been formed before the existence of organized beings. These are granite, gneiss, mica slate, and clay slate, which occur abundantly in all regions of the globe, with quartz rock, serpentine, granular limestone, &c. which occur more sparingly. These rocks never contain organic remains, and, till lately, were supposed never to cover rocks containing them; but a larger experience has shown, that this circumstance does not hold true entirely, even of granite itself. (Daubuisson, II. 226.) 2. Rocks containing organic remains, or generally associated with other rocks in which such substances are found, and which, as having been formed posterior to the existence of organized beings, are termed *secondary*. These are greywacke, sandstone, limestone, and gypsum of various kinds, slate clay, with certain species of trap, and they are found lying above the primary, or older rocks. 3. Above these secondary rocks, beds of gravel, sand, earth, and moss are found, which have been termed *alluvial* rocks or *formations*. 4. The name of *volcanic formations* has been given to beds of lava, scoriæ, and other matter thrown out at certain points of the earth's surface by subterranean fire.

Arrangement of Rocks.

A very distinct arrangement can be traced among these rocks, though they present a confused appearance to the eye on a first view. Where those of the primary and secondary classes are exposed together, the granite, which generally exists in unstratified masses, is found almost invariably under all the others; and yet it also occupies the highest points of the earth's surface. The gneiss, which is merely a stratified granite, lies next it, then the mica slate, then the clay state. The primary limestone, trap, serpentine, &c. lie in occasional beds intermixed with these. And above all, the primary formations are greywacke, sandstone, and other secondary rocks. Farther, the primary rocks are in general highly crystalline in their structure, and at the points where they are exposed to view, are found standing on their edges, or inclining to the horizon, seldom at a less angle than 45°. The secondary rocks again have rather the appearance of mechanical deposites; they occupy a more horizontal position; and their upper edges, or *outgoings*, are generally found at a lower level than those of the primary class. On these facts, geologists have founded certain general conclusions. From the oblate spheroidal figure of the globe, and the arrangement of its superior mineral masses in beds, or strata, they assume that the whole, or at least the outer crust, was at one time in a fluid state. That the central nucleus, of which we know nothing, is encompassed round and round by a coat or shell of granite, which, crystallising from a fluid state by the force of a strong affinity, has assumed a very irregular figure, shooting up into elevated cones or ridges at some points, which form the naked summits of mountains, and sinking into vast cavities many miles, or dozens of miles, below the present surface at others. That the gneiss crystallizing next in order was deposited above the granite, covering all the lower parts, but leaving the most elevated points of the granite bare. That the mica and clay slate

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were deposited in a less perfect state of crystallization above the gneiss, and in beds rather less inclined; that the older class of secondary rocks of a composition more mechanical than chemical, were then deposited above the mica and clay slate; the newer secondary rocks again above the older, in a position approaching more and more to the horizontal, as their structure became less crystalline, and occupying a lower and lower level; so that the edges, or outgoings, of the older rocks are always found rising above one another, as you advance from low plains to the summits of mountains. It is thus supposed, that the gneiss and other stratified primary rocks are found in beds nearly vertical, because we see them only at those points where, resting on the elevated crests of the fundamental granite, they break through the secondary formations; but that, if we could penetrate through the masses of sandstone, limestone, &c. which cover them in level situations, we should find them there also, and lying in horizontal positions above the granite. Farther, we see how the deposition of the different formations brought the earth nearer and nearer to the state in which we find it. The deposition of the granite, we may suppose, left the surface divided into profound cavities bounded or broken by ridges or pinnacles with steep sides, on which few orders of animated beings would have existed. The stratified primary rocks, deposited on the bottom and sides of these cavities, filled them in part, the older secondary rocks, falling down in less inclined strata, reduced the inequality still farther; and the newer secondary rocks, subsiding mechanically in strata nearly horizontal, made the surface assume a tolerably even and regular appearance. Last of all, the masses of gravel, sand, earth, marl, and other alluvial matter, filling up the smaller crevices and hollows left by the newest rocks, smoothed the surface, and prepared the earth for the nourishment of vegetable substances, and the habitation of animated beings.

We give this outline of the structure of the globe according to the principles of Werner; because, though it cannot be easily reconciled with all the facts now known, it explains the general disposition of the parts of the earth's surface, better than any other that can be given in a small compass. Of the modifications lately suggested, the following is worthy of notice. The great space which the stratified primary rocks occupy, compared with granite, and the fact, that the former sometimes preserve the same direction and dip unaltered on both sides of a granite mountain, have led some to consider the latter not as the fundamental rock, but rather as existing in large kernels or isolated masses, which are stuck in among the strata of the primary schistus, without affecting their dip and direction. The schistus again, instead of being in coats wrapped round the granite, is supposed rather to affect a *squamose* structure, or to be disposed in a continued order like the scales of a fish. Gneiss, mica slate, and clay slate, may be conceived, on this hypothesis, to be disposed in strata standing out edgeways, and alternating with one another, all round the globe. The large hollows left in the surface by the irregularity of the crystallization, or produced by the wearing away of the softer rocks (the mica and clay slate, the more destructible rocks, being generally found in the lowest situations, and the more enduring gneiss, with its kernels of granite, in the highest), are filled up by newer formations, sometimes in conformable positions, but more frequently lying over the ends of the older strata. In this place, it is enough to have mentioned these opinions, without attempting to discuss their merits.

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Changes on the Surface.

The phenomena of geology show, that the original formation of the rocks has been accompanied, in nearly all its stages, by a process of waste, decay, and recomposition. The rocks, as they were successively deposited, were acted upon by air and water, heat, &c. broken into fragments, or worn down into grains, out of which new strata were formed. Thus the disintegrated materials of the older rocks, reunited by a cement, constitute those strata of greywacké, conglomerate, and old red sandstone, which skirt the primary mountains; the debris of the secondary rocks are found aggregated in the same way into beds of breccia, tufa, and newer conglomerate; a large portion of the spoils of the slate and trap rocks, both old and new, in a state of great comminution, are spread over the surface in beds of clay; and a still larger portion of the spoils of the quartz rocks, form those immense beds of sandstone and loose sand which cover so great a portion of the dry land and the bottom of the sea. Even the newer secondary rocks, since their consolidation, have been subject to great changes, of which very distinct monuments remain. Thus, we have single mountains, which, from their structure, can only be considered as remnants of great formations, or of great continents no longer in existence. Mount Meisner in Hesse, six miles long and three broad, rises about 600 yards above its base, and 700 above the sea, overtopping all the neighbouring hills for 40 or 50 miles round. The lowest part of the mountain consists of the same shell limestone and sandstone which exist in the adjacent country. Above these are, first, a bed of sand, then a bed of fossil wood 100 feet thick at some points, and the whole is covered by a mass of basalt 500 feet in height. On considering these facts, it is impossible to avoid concluding, that this mountain, which now overtops the neighbouring country, occupied, at one time, the bottom of a cavity in the midst of higher lands. The vast mass of fossil wood could not all have grown there, but must have been transported by water from a more elevated surface, and lodged in what was then a hollow. The basalt which covers the wood must also have flowed in a current from a higher site, but the soil over which both the wood and the basalt passed has been swept away, leaving this mountain as a solitary memorial to attest its existence. Thus, also, on the side of Mount Jura, next the Alps, where no other mountain interposes, there are found vast blocks of granite (some of 1000 cubic yards) at the height of more than 2000 feet above the Lake of Geneva. These blocks are foreign to the rocks among which they lie, and have evidently come from the opposite chain of the Alps; but the land which constituted the inclined plane over which they were rolled or transported, has

been worn away, and the valley of lower Switzerland with its lakes now occupies its place. Transported masses of primitive rocks, of the same description, are found scattered over the north of Germany, which Von Buch ascertained, by their characters, to belong to the mountains of Scandinavia; and which, therefore, carry us back to a period when an elevated continent, occupying the basin of the Baltic, connected Saxony with Norway. (Daubuisson, *Geog.* I. 230.)

At the present day, we see rocks worn away by the action of rivers and the sea, or crumbling down by the agency of air, heat, moisture, and frost; we see sands thrown up by the ocean at other points, and carried by winds over the face of the continent; we find new lands forming at the bottom of lakes and the mouth of rivers; we find beds of solid matter thrown out by volcanoes, loose sand agglutinated into hard rock on the shores of the sea; and new stony deposits forming by calcareous solutions. Can we attribute the great changes of which we see traces, to the same causes which operate these effects under our eyes, or have mightier agents been employed? These are questions which geologists have not yet been able completely to resolve, and into which it is not necessary here to enter.

Organic Remains.

But the most interesting memorials of the past history of the globe are supplied by those myriads of remains of organised bodies which exist in its outer crusts. In these, we find traces of innumerable orders of beings, existing under different circumstances, and succeeding one another at distant epochs, varying through multiplied changes of form, yet, even in their most dissimilar appearances, exhibiting a constant analogy to one another, and to the organised bodies which still exist. What is not less interesting, the varieties in the character of these extinct beings are not capriciously distributed, but correspond pretty distinctly with the order of their position. Thus, as we pass from the oldest secondary formations to the newest, we find the forms of the animal and vegetable remains approaching more and more to those of the living bodies which now exist on the surface; so that, while the most ancient are but faintly allied by a few general characters to the present animal and vegetable tribes, the most recent can scarcely be distinguished from them.

If we examine the secondary rocks, beginning with the most ancient, the first organic remains which present themselves are those of aquatic plants and large reeds, but of species different from ours. To these succeed madrepores, encrinites, and other aquatic zoophytes, living beings of the simplest forms, which remain attached to one spot, and partake, in some degree, of the nature of vegetables. Posterior to these are orthoceratites, ammonites, and other mollusci, still very simple in their forms, and entirely different from any animals now known. After these some fishes appear, and plants, consisting of bamboos and ferns, increase, but still different from those which exist. In the next period, along with an increasing number of extinct species of shells and fishes, we first meet with amphibious and oviparous quadrupeds, such as crocodiles and tortoises, and some reptiles, as serpents, which show that dry land now existed. As we approach the newest of the solid rock formations, we find lamantins, phocæ, and other cetaceous and mammiferous sea animals, with some birds. And in the newest of these formations, we find the remains of herbivorous land animals of extinct species, the paleotherium, anaplotherium, &c. and of birds, with some fresh water shells. In the lowest beds of loose soil, and in peat bogs, are found the remains of the elephant, rhinoceros, hippopotamus, elk, &c. of different species from those which now exist, but belonging to the same genera. Lastly, the bones of species which are apparently the same with those now existing alive, are never found except in the very latest alluvial depositions, or those which are either formed in the sides of rivers, the bottoms of ancient lakes and marshes now dried up, in peat beds, in the fissures and caverns of certain rocks, or at small depths below the present surface, in places where they may have been overwhelmed by debris, or even buried by man. (Cuvier's *Essay*, S. 29, Daubuisson, I. 362.) Human bones are never found, except among those of animal species now living, and in situations which show that they have been, comparatively speaking, recently deposited.

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From these phenomena we are led to infer, that rocks now buried at a great depth, constituted, at one time, the surface of continents, and the seat of organic life; and that many orders of beings have been called into existence, and afterwards destroyed by great revolutions, which introduced new classes of mineral deposits, accompanied with new tribes of organic beings; we see farther, that among the variety of vegetable and animal forms which peopled these successive continents, aquatic plants and animals, which appear the earliest, show that the surface was long covered with water. The appearance of amphibious animals and reptiles at a later period indicates the first existence of dry land; but long posterior to these, and among the newest of the solid rocks, we find herbivorous quadrupeds, which shows, so far as our present knowledge extends, that it was only at a late period, speaking geologically, that the earth's surface was clothed with herbage, and rendered in other respects analogous to what it is at present. We find also, that, since the surface assumed this form, it has been subjected to at least two great catastrophes, apparently by irruptions of the waters. Thus the fossil remains of the herbivorous animals found in the Paris gypsum (the paleotherium, &c.) are covered by deposits containing sea-shells, and are not found again in any beds nearer the surface. Hence the waters, after the irruption which destroyed these animals, had again retired; and upon the new continent thus left dry, we find the remains of a different race of herbivorous quadrupeds (the elephant, rhinoceros, &c.), of species which are also extinct, but allied to the existing races in their generic characters. These animals are again covered by loose soil, intermixed with marine substances, which shows that a new irruption of the sea had occasioned their total or partial destruction; and when the waters retired once more, the land had been left dry, as it now exists; for the only class of animal remains above those in question belong to the species now

living on the surface, and are found in situations where their appearance is easily accounted for. It is among these last that the remains of the human species are found; and no vestiges of any being analogous to man in structure have ever been discovered among older deposits. *

From an attentive consideration of the phenomena now referred to, we are led to conclude, that the appearance of man upon the face of the globe is, geologically speaking, a very recent event; before which the earth had been inhabited for thousands of years, by various families of plants, and tribes of animals, which had been destroyed and renewed in a long series of successions. Farther, the researches hitherto made favour the supposition that the tribes of living beings existing at each epoch were not a remnant of those destroyed by the preceding revolution, retaining the same forms, or changed and modified by external causes, but rather a new creation, adapted, we may presume, to the altered situation of the surface. It is possible, but rather improbable, that the present races of animals may have existed along with the mastodon of America and the mammoth of Russia; but we are almost certain that they did not exist, at least in this part of the globe, with the preceding order of beings, the paleotherium, anaplotherium, &c. The continual approaches which the newer orders of fossil animals make in their forms to those now living can, therefore, only be regarded as a proof that the climate, soil, and circumstances to which the nature of the extinct species was adapted, approached more and more to those under which animal life exists at the present day.

As new orders of beings have been introduced at each change, and the most perfect have appeared the last, have we any reason to believe, from the consideration of these phenomena, that some future convulsion of nature may bury the present races of men and animals, and usher in a new creation, of a still more perfect kind, over which some intelligent being, of a higher class than man, may preside? We think not. The great revolutions, which have so often overwhelmed and new-peopled the face of the globe, seem to have been continually decreasing in the magnitude of their effects, from those which deposited the vast masses of the primitive rocks, to those which left behind them the Paris gypsum and other superficial beds, like a slight sediment in the cavities of preceding formations. They may be compared, in fact, to the motions of a pendulum, which describes a smaller arc at each vibration, till it ultimately settles in a state of rest. The progressively diminishing extent of these successive changes give us reason to believe, that the system of our globe has nearly reached this state of repose. Perhaps, without an improper licence of conjecture, we may explain the phenomena which the past history of the globe presents, by supposing that the Deity, having deemed that state of the earth's surface which we now witness the best adapted for man, and having considered a long series of changes, such as geology reveals to us, the fittest means of bringing it to this state, did, from the impulse of that benevolence which has peopled every leaf with sentient beings, create tribes of living creatures at each successive epoch, adapted to the existing order of things, and terminating with it. Nor is there any thing in this conjecture inconsistent with revelation. It has been allowed, that the word "day," in the Mosaic account of the creation, may mean a period of indefinite length; and nothing more is necessary to remove every essential difficulty. Cuvier deduces, from certain progressive changes on the earth's surface, as well as from the concurrent traditions of many nations, that the first appearance of man on the face of the globe, or at least the renewal of the human race after some great catastrophe, cannot be referred to a period farther back than about 5000 or 6000 years from the present time. (*Essay*, Sect. 34.) The researches of science in this respect afford a striking confirmation to the testimony of the sacred historian.

Varieties of the Surface.

The earth's surface may be divided into dry land and submarine land. The dry land consists of high country, that is, of mountains and hills, with the elevated valleys between them; and of low country, or the extensive plains which lie at the foot of the mountains. The sea has also its plains, mountains, and valleys. High or Alpine country sometimes descends to the sea by a succession of valleys below one another, sometimes by one large plain. Elevated and extensive plains, however, with opposite declivities, do not terminate in one another, but are almost always divided by land of a mountainous character.

Mountains.

Single detached mountains are rare, except in volcanic districts, and in those where trap rocks abound. Mountains are generally found in elevated bands, consisting either of one central chain, with branches running off at right angles, or of several chains or ridges running parallel to each other; and in both cases often accompanied by subordinate or dependent chains, of a smaller elevation. Thus the Cevennes, Jura, Vosges, with the mountains beyond the Danube, are considered as dependencies of the Alps. Mountain chains have generally a great length, compared with their breadth. The ends or extremities of a chain and the outer ends of its branches seldom decline gradually into the level country, but rather terminate abruptly. In principal chains, the highest point is generally near the middle; but in dependent chains, the highest part is that which is nearest the principal. Peaks or elevated summits, rising far above the other parts of the mountain, such as Mount Blanc, in the Alps, are generally placed on the principal ridge, or that which parts the waters, and at the point where two opposite branches join. To this, however, there are exceptions. *Cols* or necks, which are the lowest parts of ridges, and serve as passages from one country to another, are al-

* Some human bones are said to have been found in loam in gypsum caves, associated with the remains of the rhinoceros and fossil horse. Jameson's *Manual of Mineralogy*, p. 445.

most always placed at the joining of two opposite valleys. The Col de Brenner, the lowest of those in the great Alpine chain, is 4680 feet above the sea. The other four principal passages through the great chain are from 6500 to 8000 feet high. The lowest passage in the chain of the Pyrenees is about 3400, and in that of the Andes of Quito 12,200, feet above the sea. The summits of great chains sometimes present a sharp ridge, like the Swiss Alps; sometimes a level track, like Mount Langfield in Norway, which is ten or twelve leagues broad; sometimes a vast plain, like the table land of Mexico in North America, 150 leagues broad, and bounded by valleys with steep sides. Where many chains run parallel to each other, the steepest sides of the outer chains are generally turned towards the central chain; and in the dependent chains, the steepest sides are turned towards the principal. In general, also, mountains that surround lakes or basins present their steepest sides to the water. Thus the scarps of the hills which surround the Basin of Bohemia are turned inward; those of the hills which surround the Lakes of Geneva and Constance face these lakes; those of the mountains round the Mediterranean also generally face that sea; and the high lands which extend along the coasts of Africa, Asia, and America, from the Cape of Good Hope to Cape Horn, have their steepest sides to the great basin which forms the Indian and Pacific Ocean. (Daubuisson, I. 60—99.)

Valleys.

The form and arrangement of valleys correspond to those of mountains. A great mountain chain sends out branches at right angles to itself, which are called lateral chains; these lateral chains send out other smaller branches at right angles to themselves, and parallel to the great chain, and which are called subordinate chains; and sometimes these last send out others still smaller. The valleys which separate one principal chain from another, such as the valley of the Rhone above Geneva, are called "principal valleys;" those which separate one lateral chain from another are called "lateral valleys;" and those which divide the subordinate chains from one another are called "subordinate valleys." The subordinate valleys open into the lateral, the lateral into the principal; the whole forming a connected system, in the order of trunk and branches. Valleys often contract and enlarge their breadth, as if they formed a series of basins rising above each other towards their sources. Lakes are most abundant at the upper extremities of valleys. A vast number of small lakes exist along the ridge of the Pyrenees, some of them at an elevation of 8000 feet; and along that of the Andes, where they are also numerous, there are some as high as 13,000. In the Alps there are also many; but the largest, such as those of Constance, Geneva, Como, lie at the foot of these mountains, and at elevations from 650 to 1600 feet above the sea. Some of the basins, formed by the contraction of the valleys, have obviously been lakes at one period, though now dry. But more frequently the sides of valleys, instead of alternately contracting and receding, preserve a very striking parallelism, salient angles on one side being opposed to re-entering angles on the other. Nor is this the consequence of inflections in the dip and direction of the strata; for these rarely correspond with the declivities of the surface. On the contrary, we find the lateral and subordinate valleys in the sides of mountains cutting distinctly through the strata; so that, when the width is not very great, we can generally trace the same beds in the same order at the opposite sides. In short, the aspect of a mountainous region, on the great scale, is very similar to that of a hillock of soft clay or earth which has been cut and worn away by heavy rains. The furrows made by the water, ramifying into others smaller and smaller, with the little ridges of earth between them, present a very accurate image of an Alpine track, with its system of valleys, its crests and pinnacles, its long chains, and its lateral and subordinate ridges. Had the mountainous district, with some slight original inequalities of surface, been subjected, for a long series of ages, to the agents which act upon it at present, or what is more probable, to agents of the same kind, but of greater power, we have reason to believe that the configuration of the surface would have ultimately been very similar to what we see. It does not follow, however, that mountains have really received their form from such causes. (Daubuisson, I. 85—94, 245.) On the other hand, a *debacle*, or great current, such as some geologists have supposed, sweeping over the globe, or a particular district, could not scoop out valleys which are almost universally shut at one extremity.

Hills are less regular in their direction and form than mountains. They exist more frequently in groups than chains, and often appear as the last undulations of the mountainous surface. (Daubuisson, I. 108.)

Volcanoes.

Volcanoes occupy but a small portion of the earth's surface; but, in consequence of the grandeur of the phenomena they present, they have always arrested the attention of mankind. About 205 are known, including only those that have been active within a period to which history or tradition reaches. Europe contains thirteen or fourteen, and of the whole number, it is computed that 107 are in islands, and 98 on the great continents. Very few of these are in constant activity; the greater number sleep for long periods, and some of them for ages. In general their activity is in the inverse ratio of their size, and of those that are active, very few throw out lava, the greater number only emit smoke, or smoke and ashes.

In a volcano that has been in a state of repose, smoke appears before an eruption; subterranean noises are heard; the earth shakes; then ashes, sand, stones, are thrown out; at last, the melted lava runs over the crater, or bursts through the sides, after which the earthquake ceases. The columns of smoke consist chiefly of aqueous vapour, with carbonic sulphuric or muriatic gas. The ashes, which seem to be lava in a state of very minute division, have been known to be carried by the wind fifty or an hundred leagues. When deposited in great quantities, and impregnated with moisture, they form a volcanic tufa, which is sometimes solid enough to serve as building stone. The sands which form the major part of the ejected matter, and the

principal mass of some volcanic mountains, consist of minute portions of lava which congeal in the air, or of the finer scoriæ. They are mixed with crystals of augite and felspar. The scoriæ consists of larger portions of the same matter, and has the appearance of the slag of forges. Along with these and the lava are often thrown out unfused fragments of the rock, which forms the walls of the volcano. The velocity of projection is thought to equal that of a cannon-ball, and the force is prodigiously great. Vesuvius throws up large stones 1200 yards above the crater, and Cotopaxi has launched a fragment of an hundred cubic yards (weighing not less than 200 tons) to a distance of three leagues.

The lava which flows out of volcanoes is a dark stony substance, resembling basalt, compact or porous, or with imbedded crystals. It is seen lying in the bottom of the crater in a state of incandescence, like melted metal in a furnace. It has a motion like boiling; and is seen to swell up from time to time twenty or thirty feet; as it rises, bubbles, some feet in diameter, form on its surface, and explode with a noise like a clap of thunder, bursting into a thousand fragments, which are accompanied with smoke and sparks. It then sinks in silence, to rise again in a little time. These alternate swellings and subsidings are evidently produced by the disengagement of elastic fluids. The force of the fluids, however, is rarely sufficient in the large volcanoes to raise the lava to the surface; and hence, in such cases, it generally happens that the flank of the mountain is burst through by the pressure of so vast a column, and the lava escapes laterally. Of ten eruptions of Mount Etna, nine have been by the flank, but Vesuvius, and other small volcanoes, habitually throw out their lava by the crater. On the other hand, the gigantic volcanoes in the Andes, having their sides compressed by the immense mass of the Cordilleras, are never known to throw out lava now in either way, though lava is found in the country. Scoriæ and ashes, however, are still ejected. The current of lava descends in general slowly, but sometimes with a velocity of five or six miles an hour. The surface cooling first, forms a sort of tube or tunnel, under which the liquid mass is sometimes seen to flow upwards, in consequence of the pressure of the column behind. These tubes, and inclosed portions of gaseous fluids, often form caverns. When the lava first issues out, it is very fluid, but becomes more viscous as it cools. By means of its solid crust, however, it preserves its heat an astonishing length of time. Spallanzani saw a piece of wood take fire in lava three years and a half after it was thrown out, and at a distance of two leagues from the crater. It has been seen flowing ten years, and smoking twenty-six years, after its ejection. The currents are of various magnitudes. At Vesuvius one was observed eight or ten yards thick, from 100 to 400 broad, and four-fifths of a mile long; but there have been others much larger. In Iceland, in 1783, there was a current twenty leagues in length, by four leagues in breadth. So vast is the quantity of ejected matter in some instances, that the mountain of Jorullo, in Mexico, 1600 or 1700 feet high, standing on ground which was formerly a plain, was thrown up by an eruption in 1759.

Currents of water, accompanied with mud, sometimes descend from volcanoes. The water is believed to proceed generally from heavy rains falling on the exterior of the mountain, and occasioned by the sudden change of temperature round the crater; sometimes, however, from reservoirs in the interior; sometimes also, as indicated by the fish thrown out, from the water of brooks finding its way into the bowels of the mountain. Spallanzani thinks that part of the tufas of Italy owe their origin to eruptions of mud. In Cotopaxi, which rises above the line of perpetual frost, the melting of the vast masses of snow, when ignition takes place, produces most destructive torrents, one of which swept away a village thirty leagues from the crater.

Air and Mud Volcanoes.

The name of *Air* or *Mud Volcanoes* has been given to certain spots where gaseous fluids, or mud, or water (generally salt), issue out of the earth, but these have no connection with subterraneous fire. At Macalouba, in Sicily, large bubbles of gas, consisting chiefly of hydrogen, formed at some depth, rise to the surface, where they explode, and scatter the soft mud in which they are generated round the opening. Near Modena, there are a number of cones from which, at times, hydrogen gas issues, with explosions which resemble small earthquakes, while stones of several hundred weight are launched to the distance of some yards, and currents of mud are vomited forth 1000 yards in length. In some cases, the gas issues pure from chinks or caverns, and, taking fire, exhibits columns of flame 100 yards in height. The fire-worshippers in Persia built their temples over these fountains of flame; and the Chimera, with many other fables of the Greeks, had their origin in the same natural phenomena. Eruptions of mud and gaseous exhalations have been observed in the Crimea, in Java, in the American province of Carthagena, and many other places.

In the district of the Cevennes, in the south of France, there exist above 100 conical hills, which are known to be volcanic by their form and composition, consisting of mixed masses of lava, scoriæ, and volcanic stones, and exhibiting in many places very distinctly the appearanee of a crater. But they have never been in a state of ignition within the periods to which history reaches, and are therefore considered as extinct volcanoes. Many mountains in other countries present the same volcanic character, though they have never been known to produce eruptions.

Recent observations strongly favour the opinion that many of the trap rocks are the productions of subterraneous fire. But if we confine our view to those mineral masses which are recognized as volcanic at present, they form but a very trifling part of the outer crust of the globe. Their formation is obviously posterior to that of the other solid rocks, for they are always found at the surface, and never enter into the frame-work of the earth. Vesuvius has, perhaps, covered with its ejected matter twenty square leagues, and Etna one hundred. The 200 existing volcanoes, estimated according to this scale,

besides elevating their respective cones, may have spread a coat of lava and scoriæ, probably an hundred yards thick, over 20,000 square leagues, that is, over the twelve hundredth part of the surface of the globe. It may, therefore, be safely held, that volcanoes, as they now exist, have exercised no general influence on the state of the globe.

Theory of Volcanoes.

A satisfactory theory of volcanoes is yet wanting; but some progress has been made in generalizing the phenomena and circumstances connected with them which, when fully known, will certainly conduct us to the knowledge of their causes. First, water seems to be a necessary agent in the production of volcanic fire. Columns of aqueous vapour ascend from volcanoes; currents of salt water sometimes flow out of them, and heavy rains increase their action. It is only extinct volcanoes, like those of Auvergne, that are found far inland; the others are always at no great distance from the sea; the most active are in its immediate vicinity, and some are actually submarine. The matter which feeds them does not seem to be universally diffused, but rather collected in particular spots. Hence, they almost always exist in groups. Thus, Sicily and the south of Italy present us with one group, Iceland with another, the Archipelago with a third, the Canary Islands a fourth, and the great cones of Cotopaxi, Tungurahua, and Pinchincha, in Quito, a fifth. This proximity of situation in the members of the same group seems to arise, not from any subterraneous communication, but from the matter which feeds them being distributed over the space they occupy, and accompanied with the presence of the agents that excite combustion. Thus, the action of one of the volcanoes belonging to the same group, such as Etna, Vesuvius, Stromboli, is found to be entirely independent of that of the others, one being asleep while another is active, and eruptions of one producing no change in the others. The arrangement of some of these groups is perhaps most consistent with the supposition of the matter being disposed in beds; but that of others, such as the volcanoes of Mexico, and the extinct volcanoes of Auvergne, which are ranged in strait lines, rather suggest the idea of the matter being lodged in veins. The distance of some volcanoes from the sea or from large lakes, with which analogy leads us to conclude that they have a necessary connection, the length of time they have burned, and their being the focus of earthquakes, which are felt over a great extent of surface, show that the fire is seated at some distance under the surface; on the other hand, we have every reason to believe, that wherever the source of the heat may be, the erupted matter does not come from a very great depth in the bowels of the earth. The quantity of lava is too trifling to be thrown up by a central fire, or to restore the equilibrium of nature, after it has been disturbed by convulsions so dreadful as those which precede an eruption must be, if their seat is really at a very great depth in the solid mass of the globe. Neither the supposition of beds of coal, nor of pyrites, in the interior of the volcano, explain the origin of the carbonic generated so abundantly and maintained so long. Perhaps the violent heat produced in some chemical processes, as when the pure metallic bases of potass and soda, are brought into contact with oxygen, chlorine, or water, may give us an idea, though only in the way of analogy, of the source whence subterraneous fire is derived. (Daubuisson, I. 160, 192, 208, 218.)

In an article like this, we cannot attempt a detailed description of the physical features of each country, and must therefore restrict ourselves to a very general survey of the two great continents, the old and the new.

General View of Old Continent.

If we consider the old continent attentively, we shall find that its general form, the declivity of its surface, and the course of its rivers, are chiefly determined by one great zone of mountains which traverses it from one extremity to the other, at the mean latitude of 40° north. This Alpine girdle has its origin on the shores of the Atlantic between the parallels of 30° and 42°, from which, in several chains, under the names of Atlas, on the south, and the Pyrenees, Alps, Mount Hemus, on the north, it passes into Asia; and there, under the names of Taurus, Caucasus, and Elbourz, it is continued eastward to the 70th degree of longitude. At this meridian it divides into two branches, one of which, the Himalayah range, takes a direction south-eastward, and terminates within 400 or 500 miles of the Gulf of Bengal; the other, Mount Altai and Yablounoy, passes north-eastward till it strikes the Pacific Ocean at the latitude of 55°. Its entire length to east longitude 140 is 8000 miles. Its breadth varies from 500 miles to 2000. The Pyrenees, Alps, and Mount Hemus, ought evidently to be considered as members of one great group with Mount Atlas. They rise under the same meridian, and have a corresponding direction; they are not separated by open plains, but by a long and narrow inland sea, which, from its steep shores, and great but irregular depth, has exactly the character of one of those profound lakes that occupy the bottom of valleys between the parallel ridges of the same mountain chain. The Sierras of Spain, the high ridge of Corsica and Sardinia, the Italian Appenines continued through Sicily, and the mountains of Southern Greece, form so many transverse branches connecting the great southern and northern chains of the band. Perhaps most of these transverse branches, where they meet the waters, are continued by submarine ridges. At least this is the case with the connecting branch of the Appenines and mountains of Sicily; for, though the Mediterranean generally is too deep for soundings, there is no more that 100 fathoms anywhere between Sicily and Cape Bon. Through the mountains of the Morea, and Crete, and Mount Rhodope, the African and European chains are connected with Mount Olympus and Taurus. The Carpathians and Erzegebirge are dependant chains of the Alps. Mount Taurus, reinforced by the chain of Lebanon, turns north-eastward round the sources of the Euphrates, where it unites with the lofty group of Caucasus. From this the principal chain passes round the bottom of the Caspian Sea, under the name of Elbourz, including the high peak of Demawend. A collateral branch passes south-eastward, along the basin of the Tigris,

the north side of the Persian Gulf and Indian Sea, till it sinks into the sandy plains at the mouth of the Indus. Between these two run various ridges in different directions, but generally with a certain degree of parallelism to the outer chains, the whole of which give the character of table land to the surface of Persia. About 70° of east longitude the great band parts into two branches, one of which, in several chains, runs south-eastward, forming a lofty barrier to Hindostan on the north, and giving birth to the Indus, the Ganges, and the Burrampooter. The other, the Altai branch, proceeds north-eastward to the sea of Otchosk, sending off several small branches on both sides. From Uda, in latitude 55°, it skirts the sea to Behring's Straits. These two great branches support the high plateau of Thibet, within or near which all the largest rivers of Asia have their source.

Height.

The height of this great Alpine zone is various. Mount Atlas, according to Chenier, is covered with eternal snow, and must therefore exceed 10,000 feet in elevation. The Sierra Nevada, in the south of Spain, is 11,660 feet high; the loftiest summit of the Pyrenees is 11,283 feet, of the Alps, 15,646 feet, of the Carpathians, 8640 feet, Mount Etna, 10,963 feet, Mounts Orbelus, Olympus, and Parnassus in Greece, from 6000 to 9000 feet.* With regard to the Asiatic mountains, very few of their heights have been measured. We know generally that Mount Taurus, in the south of Asia Minor, Mounts Caucasus, Ararat, and Demawend, reach the limits of perpetual snow, and must therefore have an altitude exceeding 9000 feet. But the most elevated part of this mountain band is the Himalayah, the loftiest summits of which, according to the estimate of Captain Blake, rise to the height of 25,000 and 28,000 feet above the level of the sea, and are therefore the most elevated land on the globe. (*Edinburgh Philosophical Journal*, No. X. 408.) The Altai chain is but little known. Various circumstances show that it does not generally rise to a great height above the surrounding country, but it stands upon a very elevated base, and the extreme rigour of the climate proves that its absolute height is very great. Taking the whole Alpine band together, we shall probably not err far, if we reckon its mean height in Europe from 4000 to 9000 feet, and in Asia from 5000 to 14,000.

Apart from this principal system of mountains, we have two small and separate chains in the northern part of the old continent. These are the Dofrines, 1000 miles long, with a mean height from 4000 to 6000 feet, and of which the mountains of Scotland and England may be considered a detached portion; and the Urals, 1400 miles long, and of a moderate but unknown height. Both of these chains run south and north, or nearly at right angles to the grand central band. The Dofrines have a system of declivities and rivers dependent on them, embracing the whole peninsula of Scandinavia. The Urals seem to produce almost no effect on the general direction of the surface and of the rivers in the great northern plains.

This great Mediterranean band of mountains may be considered as the spine of the ancient continent. It determines the direction and elevation of the surface, over nine-tenths of Europe and Asia, and one-fifth of Africa, the course of all the great rivers in the old world, except the Nile and the Niger, and in some measure the climate of the different regions. It incloses within its extreme branches Spain, Barbary, Italy, Swisserland, Southern Germany, Hungary, the Mediterranean Isles, Turkey in Europe and Asia, Persia, Bucharia, Thibet, and Chinese Tartary, all of which countries consist either of table land, or of valleys placed between the different chains. The surface of this mountainous zone occupies a space of 5,000,000 square miles, and embraces Persia, Phenicia, Assyria, Asia Minor, Greece, and Italy, all the early seats of civilization. Spain consists of a succession of valleys from 500 to 2500 feet high, divided by ridges, and in the central parts, especially in the basin of the Douro, approaching to table land. Southern Swisserland and the Tyrol present us with profound valleys from 1000 to 3000 feet above the level of the sea. Northern Swisserland, Wirtemberg, Bavaria, and Austria, consist chiefly of irregular plateaux from 1000 to 2000 feet high, broken by mountain ridges. Italy embraces merely the declivities of the Appenines, Barbary those of Mount Atlas. Greece consists of narrow littoral declivities, and basin-shaped valleys; and the Mediterranean Isles are merely the summits and sides of marine mountains. Bohemia is a circular valley, the bottom of which is probably 500 or 600 feet high; and Hungary a still larger and more level plain, whose bottom, according to Humboldt, is not more than 200 or 250 feet above the Black Sea. Asia Minor is an irregular elevated plateau, fenced on the south by Mount Taurus, and declining generally to the north. Persia, according to Olivier, is also a high plateau, supported on all sides by mountains, and depressed in the middle, so that the waters never penetrate the external barrier, but flow inwards, and stagnate, or disappear by evaporation. Thibet is a plateau of the same kind, but still more extensive and more elevated, forming, in truth, the summit of the Asiatic plains, and the most extensive and lofty range of table land on the globe. From a single fact respecting its climate, Humboldt has inferred that the height of this great plain is from 9000 to 10,000 feet above the sea. Thibet, with the desert of Shamo, which is merely its continuation to the north-east, are supposed to comprise a surface of 1,500,000 square miles. From the little that is known respecting these regions, they are believed to consist of level sandy or stony plains, diversified by mountains of moderate height, and by pastures with inconsiderable streams, which generally lose themselves in salt lakes or marshes. In the eastern part, the country of the Kalkas, though it rises perceptibly from China, the elevation cannot be nearly so great as Mr Barrow supposes, for some of the

* Notes to Leslie's *Geometry*. Articles EUROPE and GREECE, in this *Supplement*.

hills in latitude 45° and 50° are covered with wood, which does not grow on Caucasus (in a corresponding latitude) at more than 6400 feet of absolute height.*

Great Northern Plain.

The region on the north, exterior to this great mountain zone, but subordinate to it, is remarkably simple and uniform in its character. Commencing from the eastern shores of the North Sea and the Baltic, it extends in one vast plain, unbroken by a single chain of mountains, except the Urals, to the North Pacific Ocean. This plain, the largest on the globe, including generally the whole space between the 50th and 70th parallels, has an average breadth of 1400 miles, and a length of about 6000, and comprehends an area of 6,500,000 square miles, or rather more than one-fourth of Europe and Asia. It embraces the western part of France, all Holland, Northern Germany, Prussia, and the whole of Russia. Of its western division, that part which comprises France has considerable inequalities of surface, coasts generally rocky, and a good soil, which declines to the west. From Holland to Jutland it is chiefly a heathy or marshy *steppe*, very low and level, and with flat shores. From Mecklenburg to the Gulf of Finland, sands are more abundant than heath, the shores are flat, the surface, which is low and abounding in shallow lakes, declines to the Baltic for a breadth of 250 miles. From the longitude of 30° to the eastern extremity of Asia, a vast plain extends, one-fifth of which declines to the Black Sea and Caspian, the other four-fifths to the Frozen Ocean. Between the parallels of 50° and 60° the soil is generally capable of culture, and in many places rich, but it is intermixed with extensive sandy deserts impregnated with salt, and abounding in salt lakes. There are large forests, but the surface is, for the greater part, little wooded, presenting extensive open pastures, which are denominated *steppes*. Beyond the 60th parallel the ground is generally frozen during the whole year, and incapable of culture, but produces some low and stunted wood as far as the parallel of 65° or 67°, and grass or moss to the borders of the Frozen Ocean. The rivers eastward of longitude 55° have all their courses northward; they have little declivity, and are navigable almost to their sources, for the few weeks they are open.†

Zone of Sands.

South of the great central band of mountains, we have an immense zone of sandy deserts, 900 miles broad, and 4500 long, extending between the parallels of 18° and 31° north, and between the west coast of Africa, and the mouth of the Persian Gulf. But, in reality, the sandy zone includes also the eastern part of the great Alpine girdle. It is, therefore, more accurate to consider it as extending across the African continent in a band of 13 degrees in breadth. From the Red Sea it turns a little to the northward, and in the form of a truncated triangle, resting upon this sea as a basis, it reaches obliquely across the continent of Asia to the 50th degree of latitude, and the 120th of longitude; including northern Africa, Arabia, Persia, Cabul, Bucharia, Sind, Thibet, and the western part of Chinese Tartary; and embracing an area of 6,500,000 of square miles, or nearly one-fourth of the two continents through which it passes. This tract contains many mountains, and some fertile valleys, but it is characterized by vast desert plains, formed of very light moveable sands, which assume the form of waves,—by burning and pestilential winds,—by an extraordinary aridity and want of rivers,—and by an abundant formation of salt, sometimes deposited like a crust on the surface, sometimes mixed with the inferior soil. Except the Indus and the Oxus, there is not a river of any size within this immense region, which is twice as large as Europe. The Sahara, or western desert of Africa, the peninsula of Arabia, and the great Plateau of Thibet, present the most continued surface of sand. Oases, or fertile spots, are found wherever the springs break through the upper sandy stratum. These oases are comparatively numerous, and extensive, in the eastern part of Africa; while in Persia, Cabul, and Bucharia, the surface is diversified with green mountains, which give birth to fertilizing streams. Of the whole sandy zone, however, it is probable that three-fourths consist of irreclaimable deserts.

South Africa.

South from the Sahara in Africa lies a comparatively fertile tract, the basin of the Niger, the Senegal, the Gambia, and the upper basin of the Nile. This is bounded on the south by the ridge of Jebel Kumra, a mountain of moderate height behind the coast of Guinea, but rising to the region of the perpetual snow in Abyssinia, if the two are really parts of one chain. Little is known of the great southern extremity of Africa, extending from these mountains to the Cape of Good Hope. From the elevation of the coast, and the smallness of the rivers, it may be conjectured to consist chiefly of table land, and to be distinguished by its aridity.

South Asia.

From the head waters of the Ganges, a low and level tract extends to its mouth, and from this to Cambodia, a series of long valleys opening into marshy plains at the shore. The triangular peninsula of India, and the rich country of China on the opposite sides of this tract, are covered by considerable mountains, and have the character of table land. The group of islands which extend from China and Malacca to New Holland are in general full of elevated mountains, many of which are volcanic. New Holland has some of its shores low, and some elevated, but it is not known to possess any very high mountains, or any large rivers. Of the innumerable small isles scattered in the Pacific, the greater part are merely the summits of coral reefs.

South America.

The New World forms two great continents, united by a neck of high land. South America consists of one vast expanse of surface of small elevation, everywhere protected on the west by the great

* See Barrow's *Travels*. Gerbillon's *Journies* in *Histoire Generale de Voyages*, Tom. IX.

† Walckenaer, *Cosmol.* 408, 412. Sauers's *Narrative*. Pallas's *Travels*.

rampart of the Andes. These mountains, which pass along the western coast, at the distance of from 50 to 150 miles from the sea, rise, in one of their summits, to the height of 21,440 feet, and in Peru have a mean elevation of about 12,000 feet. There are three small transverse ridges, one in Caraccas, at the latitude of 8° or 9° north; another, which divides Guiana from the basin of the Amazon; and a third, which parts from the Cordilleras in south latitude 18°, proceeding eastward, and spreading out into a range of table land as it approaches the eastern coast. All these transverse chains are of small elevation. The low region of this continent is divided into three great plains, which form the basins of the three principal rivers, the Orinoco, the Amazon, and the Plata. In the basin of the Orinoco, the eye is fatigued by the unvaried aspect of a boundless level, uniform as the surface of the ocean, without a plant, or any object a foot in height, to break its monotony. Except on the borders of the rivers, these plains are destitute of trees. After the annual rains, they are clothed with a luxuriant herbage, which, during the heats of the dry season, is reduced to dust, and disappears. The soil then presents the aspect of a parched desert, in the chinks and fissures of which, the alligator and the great serpent remain buried amidst the dry mud, till they are awakened by the first showers. The Pampas of La Plata, which extend from 18° to 40° of south latitude, are plains of the same description. But the zone which divides these open plains, and forms the basin of the Amazon, extending from 6° or 7° of north, to 18° of south latitude, is one vast and continued forest. On the eastern side of the continent, this forest extends as far south as latitude 25°, and altogether embraces a surface of 20,000 square leagues. This middle region is also the highest, but so low are all the three, that, if the sea were to rise 50 fathoms at the mouth of the Orinoco and Plata, and 200 at the mouth of the Amazons, it would wash the eastern foot of the Andes, and submerge more than one-half of South America. The Llanos and Pampas afford pasturage to millions of cattle, and are, in truth, *steppes* like those of Southern Russia. There are no real deserts in South America, except a narrow tract of rock and quicksands on the coast of Peru between Coquimba and Lima, on which no rain ever falls. (Humboldt, *Pers. Nar.* IV. 292, 311.)

North America.

The North American continent, like the South, is distinguished by one great chain of mountains, which traverses it from south to north nearly through its whole extent, leaving a large open level region to the east, and presenting a steeper and narrower declivity to the west. The chain of the Rocky Mountains, which ascend considerably above the inferior limit of perpetual snow, at latitude 46°, has probably an elevation of 8000 or 9000 feet. In a general point of view, these mountains determine the declivities of the soil, and the course of the rivers over nearly the whole continent. On the west side of the chain the slope is rapid, and the rivers, so far as they are known, flow directly to the Pacific Ocean, passing through a high, broken, interrupted chain, which skirts the coast. On the east side, they bend their course to the nearest sea, over a surface little inclined, flowing to the north-east, and north in the northern parts, and to the south-east and south in the southern parts. On looking attentively at the rivers in the map, it will be perceived that the chain of lakes above Lake Erie, the upper Mississippi, the Missouri, the Arkansaw, and Red River, all point in one direction, to the south-east, that is, at right angles to the general line of the coast, reckoning from Nova Scotia to the north-west corner of the Mexican Gulf. But, as if the barrier of the Alleghanies had been thrown up subsequently to the general level of the surface being settled, we find the St Lawrence and the Mississippi, after running nearly parallel till they were within 500 miles of the coast, suddenly deflected from their south-east course, and proceeding to the sea in directions almost exactly opposite. The mean height of the Alleghanies is from 2000 to 3000 feet.

The woods are thickest on the eastern side of the Alleghanies. In the basin of the Ohio, which occupies the western declivity of these mountains, extensive tracts, called prairies, destitute of trees, but covered with herbage, occur. The declivities of the rocky mountains from the Mississippi to the Pacific Ocean are generally bare of wood, except along the rivers, and within twenty leagues of the sea-coast. In truth, the whole of this vast region consists of open steppes or savannahs, of a rich soil, and affording excellent pastures, but mixed with stony and sandy tracts, especially towards the Mexican frontiers. Salt springs are numerous, and in some districts the surface is incrustated with a saline efflorescence. The whole of the region east of the Rocky Mountains, from the 50th parallel to the Arctic Sea, is generally low, abounds in lakes, and is scantily wooded as far as the 60th degree of latitude, beyond which trees cease to grow. From the Gulf of Mexico to the mouth of Coppermine River, in latitude 67°, the country may be considered as one great plain, the summit of which, about the 50th parallel, is probably not 1000 feet high. The mean height of the great basin of the Mississippi and Missouri, Humboldt thinks, does not exceed from 500 to 800 feet. The interior of the country between Mackenzie's River and Behring's Straits, and between Hudson's Bay and the coast of Labrador, is entirely unknown; but the former is probably fertile and tolerably wooded, as the whole of the region west of the Rocky Mountains has a mild and humid climate. The late discoveries of Captain Parry and Captain Franklin have rendered it probable that the northern limits of the American Continent run generally along the 67th or 68th parallel, and that the space between this and the latitude of 78° or 80° is occupied by a numerous group of islands, of which Greenland may be considered a part. The isthmus which connects the two American continents consists of a prolongation of the chain of the Andes, of moderate height, and which, about the latitude of 18° north, spreads out into a vast plateau of table land, about 7000 feet above the sea. From this elevated base some detached volcanic mountains ascend

10,000, reaching an absolute elevation of 17,000 feet. (Warden's *America*, Chap. 31, 32, 33. Walckenaer, *Cosmol.* Chap. 14.)

New and Old Continents Compared.

A comparison of the great continents of the Old and New World shows that the advantages are greatly on the side of the latter. All the interior parts of both the American continents have the advantage of being nearer the sea than the interior parts of Asia and Africa. There are in America no great deserts like those of the Old World, which not only withdraw a vast portion of the soil from the use of man, but, by the burning winds they generate, render the neighbouring regions scarcely habitable, and, by the wild beasts and robbers to which they afford shelter, oppose a more formidable barrier to the intercourse of nations than stormy seas or snow-clad mountains. But the grand advantage of the New World is its immense facilities for inland navigation, in consequence of the little elevation of its surface and its multitude of noble rivers. The St Lawrence, the Mississippi, the Amazons, and the Plata, penetrate the heart of the two American continents in a manner to which there is nothing analogous in the Old World. By means of these great streams, and their branches, there is scarcely a district of any extent, however remote from the sea, which has not a more easy and rapid communication with the rest of the world than the countries within 200 or 300 miles of the coast in the greater part of Asia and Africa. Mexico, the only considerable region in the New World without navigable rivers, has the advantage, by the narrowness of its territory, of being everywhere near the sea. We may add, as an accidental advantage of the New World, that its aboriginal inhabitants, from the smallness of their numbers, present almost no obstacle to the establishment and growth of a civilized population; while the Old World is too thickly peopled in most of its parts to admit of being easily colonized, and by tribes who discover no aptitude for civilization themselves.

The extent of the four great divisions of the world is as follows:

		Sq. Eng. Miles.
Europe with its Isles, - -		3,432,000
Africa with Madagascar, - -		11,420,000
Continental Asia, -	16,890,000	21,090,000
The Isles, including New Holland and Polynesia,	4,200,000	
South America, -	6,420,000	15,300,000
North Do. - -	8,100,000	
Islands, - -	160,000	
Greenland (supposed),	620,000	
		51,242,000

Rivers.

Rivers are natural drains which convey to the sea that portion of the waters falling upon the earth, which does not pass off by evaporation, or go to nourish organic bodies. They invariably occupy the lowest parts of the surface of the districts from which their waters are derived, and these districts are called their basins. The basin is bounded by high lands, which are sometimes mountainous. The water descending from these collects into brooks, the brooks unite into rivulets, the rivulets united form the main trunk or river, which conveys the waters of the whole to the sea. All these descend over inclined planes, so that the lowest point of each brook is that where it joins the rivulet—the lowest point of the rivulet that where it unites with the main stream—and the lowest point in the whole system of inclined planes, is that where the river falls into the sea. These basins form natural divisions in physical geography. Thus the basins of the Rhone, Garonne, Loire, Seine, and part of the basin of the Rhine, comprehend nearly all France; Northern Italy consists chiefly of the basin of the Po, and Bohemia entirely of the basin of the Upper Elbe.

Channels how Formed.

The form and appearance of river courses lead to the conclusion that their channels are generally the work of their own currents. We never find them flowing in cavities which retain their natural shape, but always in beds cut below the adjoining surface, and corresponding to the quantity of water; the bed of the main stream being larger than those of the great branches, and the beds of the great branches larger than those of the small. They do not accommodate themselves to the inequalities of the country, but flow near the surface in low plains, and cut through a high ridge when it comes in the way; preserving a pretty uniform rate of descent, however great may be the undulations of the superior soil. The deep ravines that have been cut through hard rocks in this way, by an agent that operates so slowly, impresses us with a conviction that immense periods of time must have elapsed since the operations commenced. Before this took place, the courses of rivers must have consisted chiefly of a series of lakes communicating by cataracts. The waters flowing down from the high grounds in one district would collect and form a lake, which would increase till the flood found a passage over the lowest part of the bounding ridge, and fell into a second cavity, in which they would again accumulate, till they were discharged by another cataract into the next natural hollow. By a twofold chain of operations these lakes and cataracts disappear. The bottom of the lake is constantly rising by the earth and gravel carried down by the torrents and spread over it, and the level of the waters is constantly sinking by the action of the stream in deepening the outlet. At length the lake becomes a dry level plain, with a gravelly bottom, and the cataract a deep cleft or ravine, through which and the plain above, the river flows with a uniform and gradual descent. Many of the haughs or holms seen on river courses have undoubtedly been lakes of this kind.

Changes in River Courses.

The surface of the globe everywhere presents traces of these changes. The celebrated passage of Ecluse has exactly the dimensions and appearance of a channel cut by the Rhone itself, and exhibits marks of the action of the water far above the present surface. Three distinct basins are observed in the course of the Rhine. The lake of Constance occupies the first, the second extends from Basle to Bingen below Mentz, and the third from this to the sea; and each of these basins is separated from the others by a narrow rocky strait. In the Danube

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may be distinguished the basins of Bavaria, Austria, and Hungary, from each of which the river escapes by a mountainous defile. The celebrated defile of Tempe in Thessaly, the deep and rugged clefts by which the Potowmac, Susquehannah, and Delaware, penetrate the barrier of the Alleghanies, all bear decisive marks of the action of the stream. In many cases, the subsidence of the water can be traced from one level to another by terraces of gravel left on the sides of the mountains. In the valley of the Rhine these are seen to the number of four or five, at the distance of twenty, thirty, or forty feet below one another, and from them Professor Playfair ascertained that this river had once flowed at the height of 360 feet above its present bed.*

In the greater number of river courses we see those changes completed, but in the chain of North American lakes on the St Lawrence, we see them still in progress. On the rocky sides of some of these lakes Mackenzie observed marks of the action of the water considerably above its present level. The Niagara falls have been observed to recede about eighteen feet in thirty years, by the water's wearing away the limestone rock. This rock forms a large level platform, from the outer edge of which, six miles below the falls, the cataract has receded, and worn out a deep channel of that length by the constant attrition of its current. Had the surface of this rock dipt rapidly to the southward, the lake would have been emptied long ago. The fact is interesting in another point of view. Supposing the rate at which the rock is wasted away by the stream (eighteen feet in thirty years) to be well ascertained, and to have continued uniform, since the fall has gone backwards six miles from the position it must have originally occupied, it may be inferred, from calculation, that 50,000 years have elapsed since the waters of the St Lawrence began to flow. If we could depend upon the smaller unit—the annual waste of the rock, we should consider this as a tolerable criterion for estimating the antiquity of the present physical arrangement of the earth's surface. (Hall's *Travels*, p. 235.)

Alluvial Deposits of Rivers.

Where rivers which pass through low and level tracts are subject to annual inundation, the earth, sand, and gravel they bring down, deposited most abundantly on their banks, raise them gradually above the surrounding conntry, while a part of the matter carried to the sea enlarges the coast, or forms sand or mud banks which rise, by degrees, above the water. It is thus that the Ganges, Po, Nile, Mississippi, and many other rivers, flow on the top of ridges. During floods, the elevated sides are sometimes burst through, and the waters which escape either stagnate in lakes, or return into the main stream lower down, forming islands, or travel to the sea by a separate mouth, and form a delta. Hence the Amazons, Orinoco, Mississippi, Nile, Danube, Wolga, Ganges, abound in islands. and have deltas from 50 to 200 miles in breadth, at their mouths. In the tracts of new ground which are thus gained from the sea, the soil may be seen of every degree of solidity, from soft mud to firm land. In the broad plain at the mouth of the Ganges, between the Tipperah hills and Bardwan, wherever the ground is penetrated, no virgin soil is found, but an alluvial deposit of sand and mud arranged in strata. The finest soil transported to the sea renders the water muddy to the distance of twenty miles from the coast. The Mississippi is supposed to add about two leagues to the coast in a century, or 300 feet *per annum*, at the point where its main stream falls in. (Warden's *America*, II. 492.) But the increase, if equally distributed over the whole delta, would not exceed two or three feet *per annum*. Volney calculated, but on very loose data, that the Nile had advanced four miles at Rosetta, and ten at Damiata, since the time of Herodotus; a quantity far too great, amounting to sixteen feet *per annum* over the whole delta. But Girard ascertained, that the annual floods of the Nile had raised the surface of Upper Egypt about six feet four inches (English) since the commencement of the Christian era, or four inches in a century. Now, as the sea deepens on the coast, at the rate of a fathom in the mile, supposing the deposit to have been as great along the whole shore as in the Thebais, the addition would amount to no more than one mile and a quarter since the time of Herodotus. The great error in all estimates of this kind has arisen from confounding the changes that belong to geological with those that belong to historical periods. The Po, which sweeps rapidly through a rich valley, transports a vast quantity of alluvion, and is found to encroach upon the Adriatic, at the astonishing rate of 228 feet *per annum*, at its two principal mouths. Adria was once upon the sea, and a circular space of twenty miles in diameter must have been filled up with solid soil since it was built. Assuming that 2500 years have elapsed since the building of Adria, and allowing the new ground a depth of twelve feet, it follows, that the river must have deposited 45,000,000 of cubic feet annually at its mouth, exclusive, perhaps, of as much more floated away by the sea, or spread over the banks higher up. Even this quantity of alluvion is a trifle compared with that of the Yellow River of China, which is 2,000,000 of cubic feet *per* hour, if Mr Barrow's estimate may be credited. Great as these effects seem to be, they sink into insignificance when compared with the whole extent of the ocean. Assuming that the mean depth of the sea is two miles, and that each district of land, of the same extent as the basin of the Po, furnishes an equal quantity of alluvion, it may be shown that it would require 400,000,000 of years to fill up the present bed of the ocean.†

Periodical Inundations.

All rivers are subject to occasional or periodical floods. Those of the Nile, observed in a country where no rain falls, have been a subject of speculation since the time of Herodotus. Within the torrid

* Daubuisson, *Geog.* I. 105. Hall's *Travels in America*, p. 268, 346. Playfair's *Works*, I. lvi.

† Volney's *Trav.* I. 28. *Edinburgh Phil. Jour.* No. V. p. 53. Cuvier's *Geol. Essay, Suppl.* Barrow's *Trav.* 491.

zone, these floods are produced by the annual rains, and occur during the summer months; but, beyond the tropics, they occur at various seasons, and in high latitudes, chiefly in spring, when the snow and ice melts. As the season of rains at each parallel within the tropics commences generally when the sun passes the zenith of the place towards the pole, and continues till he pass it again on his return, or a little later, the floods, of course, last longer as we advance farther within the torrid zone, and at the equator are perpetual. Hence, the Amazons, which derives its waters from both sides of the equator, may be said to be always in flood; but as its largest branches belong to the southern hemisphere, its greatest inundations are during our winter months. Those of the Plata take place during the same season, but are of shorter duration. These floods cover a vast but unknown range of country. The Orinoco begins to rise in May, overflows its banks in June, and returns into its bed in September, but, like the other tropical rivers, continues to fall till March or April next year. The Nile, which is really a tropical river, begins to rise in June, reaches its maximum height of 24 or 28 feet about the middle of August, and continues to fall till May next year. Its increase is irregular, two or three inches a day at first, and sometimes, when near its height, as much as three or four feet. The long valley of Egypt, from three to four leagues broad, with the delta at its extremity, is now covered by the water, except some elevated spots, and the higher parts of the river's banks, which rise above the adjoining surface. In Northern India, where the seasons depend chiefly on the monsoons, the Ganges begins to swell in April, when the rains fall on the mountains, and increase at the rate of one, two, or three inches a day, till it reaches the height of 15½ feet before the showers have commenced in the plains. When the latter begin in July, the river rises at the rate of five inches a day, till it reaches its maximum of 31 or 32 feet, about the same period as the Nile. In the end of July, the low country, for a breadth of 100 miles, presents a wide expanse of water, whose surface is diversified by the trees that everywhere rise above it, and by the multitude of villages standing like islands, between which, the peasants are seen passing in boats. The rains cover the low tracts before the bed of the river is filled, and its banks, which rise above the rest of the country, appear like long mounds which separate the waters of the inundation from the stream of the river. The floods are computed to advance over the low region at the rate of half a mile *per* hour, and when at their height, cover a large tract of country to the depth of twelve feet. The floods of the Indus fertilize a district reaching thirty or forty miles on each side of its course. They attain their full height, like those of the Ganges, in August, but they begin rather later, end sooner, and are probably smaller. The celebrated Euphrates, which has its sources in the high mountains of Armenia, begins to swell in March, reaches its extreme height in April, and, from this period till June, during which heavy showers fall every day at noon in Armenia, it remains nearly stationary. After June it falls rapidly. Its extreme rise is twelve feet in Mesopotamia, and so level is the country, that, with this small elevation, it covers nearly the whole plain between it and the Tigris, in the latitude of Bagdad. The Mississippi is lowest in October; in some of its remote branches the floods commence in February, with the melting of the snows, but they are not much felt in the low country till March, from which time they mount rapidly till June, and then fall again till October. From the junction of the Missouri to that of Red River, the great volumes of water thrown by the Mississippi over its western banks, spread out into shallow lakes, which are dried up by the autumnal heats, and become parched and solid plains. Below Red River, where the delta commences, the ground is a wide swamp, rising very little above the level of the tide. The only soil capable of cultivation is the long stripe of elevated land which forms the bank of the river, and is dry during eleven months. Consisting of fine travelled earth, it is luxuriantly fertile. Its breadth is small, sloping downwards as it recedes from the stream, and at a distance, varying from half a mile to a mile and a half, terminating in the swampy level. In the rivers that water the northern parts of the new and old continents, the floods, which almost invariably proceed from the melting of the snow and ice, are violent but transitory; and occur in March, April, May, or June, according as the sources of the river are farther from, or nearer to the arctic circle. In some of these rivers there are three successive floods,—the first in March or April, when the thaw takes place in the low country,—the second in May, when the thaw has reached the middle regions, and heavy rains fall,—and the third near the end of summer, when the glaciers begin to dissolve. Thus in the frigid, as well as the torrid zone, the season of floods is generally the four months nearest the summer solstice. *

As water cannot be heaped up where it is not confined on all sides, it follows that the floods in rivers will gradually sink as they approach the sea, and assume the form of an inclined plane at their upper surface. Thus the rise in the Mississippi in the height of the inundation, at the distance of 1000, 300, and 100 miles from its mouth, is 50, 25, and 12 feet respectively. The Ganges, which rises 31 feet at Custee, rises no more than 14 at Dacca, and 6 at Luckipoor. The extreme height of the Nile, which is 24 or 28 feet at Cairo, is only 4 at Rosetta. From the great additional rapidity thus communicated, when the depth is only doubled, the discharge is often quadrupled. In the case of the Nile, where the depth is trebled, the discharge is probably augmented tenfold during the height of the flood. The

* Humboldt, *Pers. Nar.* V. Shaw's *Trav.* II. 221. Rennell, *Phil. Trans.* 1781. Kinneir's *Geog. Mem. of Pers.* 228. Morier's *Journey in Persia*, I. 342. Kerr Porter's *Trav. in Babylonia*, II. 404. Warden's *America*, II. 506. Darby's *Geog. Descript. of Louisiana*, 126, 236. Tuckey's *Marit. Geog.* I. 251.

quantity of water delivered into the sea by the rivers between the equator and the parallel of 35° north, is perhaps as great in the single month of July, as during the eight months from September to April.

The following table, which we have prepared with considerable labour, exhibits some interesting calculations with regard to the most considerable rivers of the globe. The first column of figures gives their proportional lengths, measured always to their remotest branches, the length of the Thames being reckoned unity. The second column gives the area of their basins in square English miles; the third the proportional magnitude of those basins; and the fourth the quantity of water which each discharges, that of the Thames being unity. The last column, which is necessarily hypothetical, is constructed on the following basis. The fall of rain is found to bear a certain relation to the latitude, and is assumed to be equal (though it is not strictly so) along all the parts of the same parallel. It is farther assumed, that of the rain which falls, a certain fixed proportion is received by the rivers. It is evident, then, that, having the extent of the river basin, its mean latitude, and the depth of rain at that latitude, we have the elements for computing the proportional discharge of the rivers. In the ingenious article HYGROMETRY, in the *Edinburgh Encyclopædia*, the author deduces, from data partly theoretical, the amount of rain for each 5° of latitude. But, from Cotte's Tables, Captain Parry's observations, and various facts stated by Humboldt, we have been led to conclude, that the mean depth of rain at the equator is at least 10 inches more, and at the pole considerably less than given in the article referred to. On these and other grounds we have endeavoured to connect the results of observation by an empirical rule. Assuming the annual deposit of rain and dew at the equator to be 83 inches, and at the pole 8, we find the intermediate terms by the following formula:

75. (Rad.—Sine of Lat.) $+ 8 =$ depth of water in inches.

	Rivers.	Length.	Area of Basin in English Miles.	Proportional Magnitude of Basin.	Proportional Quantity of Water Discharged *per annum.*
EUROPE.	Thames	1	5,500	1	1
	Rhine	$4\frac{1}{2}$	70,000	$12\frac{1}{2}$	13
	Loire	4	48,000	$8\frac{1}{2}$	10
	Po	$2\frac{1}{4}$	27,000	5	6
	Elbe	$4\frac{1}{2}$	50,000	9	8
	Vistula	$4\frac{1}{4}$	76,000	$13\frac{1}{2}$	12
	Danube	$9\frac{3}{4}$	310,000	56	65
	Dneiper	$7\frac{3}{4}$	200,000	36	36
	Don	$7\frac{1}{2}$	205,000	37	38
ASIA.	Wolga	14	520,000	94	80
	Euphrates	$9\frac{3}{4}$	230,000	42	60
	Indus	$11\frac{1}{2}$	400,000	$72\frac{1}{2}$	133
	Ganges	10	420,000	76	148
	Kang-tse, or Great River of China	$21\frac{1}{2}$	760,000	138	258
	Amour, Chinese Tartary	16	900,000	164	166
	Lena, Asiatic Russia	$13\frac{1}{2}$	960,000	174	125
	Oby, ditto	15	1,300,000	236	179
AFRICA.	Nile	$18\frac{1}{2}$	500,000 uncertain.	90	250
AMERICA.	St Lawrence (including lakes)	$22\frac{1}{2}$	600,000	109	112
	Mississippi	19	1,368,000	249	338
	Plata	$13\frac{1}{2}$	1,240,000	225	490
	Amazon, not including Araguay	$22\frac{3}{4}$	2,177,000	395	1280

To deduce the approximate lengths of the rivers in miles from the proportional lengths, we may multiply the latter by 180, this being pretty nearly the distance between the remotest source of the Thames, and its mouth at the Nore, following the sinuosities of the river. To convert the proportional discharge into known measures, we would multiply by 1800 to obtain the number of *cubic feet per second*, or by .4 (or $\frac{1}{10}$), to find the annual discharge in *cubic miles.*

Discharge of Rivers.

It is a question of some difficulty to ascertain what proportion of the rain, snow, and dew, which falls on the ground, passes off by the rivers. Mr Dalton, computing the annual deposit of moisture in England to be 31 inches of rain, and 5 of dew, concludes that 13 inches, or more than one-third, is drained off by the rivers. (*Manchester Transactions,* V. 359.) But this is founded entirely on a conjectural estimate, not an actual measurement, of the depth and velocity of the Thames, in the basin of which the fall of rain is only 22 or 23 inches at London and

Oxford. Since it is shown, however, by the observations of Dr Dobson, Dr Watson, and Mr Dalton himself, that the evaporation from water is about equal to the fall of rain,—that from a grassy plot in a dry season, it is sometimes 0.7 inches in a day, or $\frac{2}{3}$ of what pure water yields,—and that from ordinary soils, 30 inches out of 38 escape by evaporation, leaving only $\frac{1}{4}$ for the streams, there is surely more than a presumption that the rivers cannot carry off 13 out of 36 inches for England, and still less 13 out of 26 or 28 inches in the basin of the Thames. (*Phil. Trans. Abrd.*, XIV. 137. *Manchr. Trans.* V. 359.) The Mississippi, which drains one of the largest valleys on the globe, was found by Mr Darby to have a breadth of 2400 yards not far above New Orleans, with a depth of 153 at high, and 130 at low water. (*Geog. Descrip. of Louisiana*, p. 126.) The section considered as a semiellipse is 280,000 square feet, and the discharge, with the mean velocity of one mile an hour, which he assigns to it, is 410,000 cubic feet *per* second, equal to 88 cubic miles *per annum*. As we have taken the high water level with the mean annual velocity, the difference of 23 feet may stand as equivalent to the loss of water by the bayous, or outlets, of Ibberville and Atchafalaya, and the temporary lakes farther up. Now this discharge, distributed over the basin of the Mississippi, amounts to no more than four inches of water in depth. If we add one-half to it, on the supposition that his estimate of the velocity is rather low, even this will only raise the rain water to six inches upon the area of the basin. But the depth of rain corresponding to the mean latitude of the basin of the Mississippi (41°) is by the rule 34 inches, and at Cincinnati, in latitude 39°, it has been found, by observation, to be 36 inches. This is exclusive of dew, and from what we know of the climate of St Louis, and of Columbia river, we have no reason to think that the average for the whole basin can be much less. (Warden's *America*, II. 237, III. 121.) We would be entitled, from these facts, to estimate the depth of the watery deposit at 40 inches; but suppose we reduce it to 30, the proportion drained off by the rivers amounts only to one-fifth. From the nature of the basin of this great river, which avoids all extremes, having a moderate elevation, and consisting neither of a continued forest, nor of a sterile desert, but of a mixture of the most common varieties of soil, it affords probably as fair a criterion as could be obtained for deciding a question of this kind. We think, therefore, that both theory and observation warrant the conclusion, that, in the case of large rivers flowing over extensive and tolerably level surfaces, the water carried to the sea does not exceed one-fifth of what falls in rain, dew, and snow. Where the basins are small, the surfaces steep and rocky, and where heavy rains continued for months, keep the soil in a state of saturation with moisture, the discharge may be greater. In other cases, where the basin is long and flat, the watercourse broad and shallow, the temperature high, and the soil sand or gravel, the loss of the river by direct evaporation, and by infiltration, through its bed and sides, may be very great, and does in some cases (as in that of the Platte) absorb the whole water. The rule, of course, is not meant for extreme, but for ordinary cases. Founding then on the rate of discharge of the Mississippi, that of the Thames should be about 1800 cubic feet *per* second, or $\frac{4}{10}$ of a cubic mile *per annum*, equal to nearly five inches on the surface of its basin. This may serve when it is considered as the unit of the scale, but, in point of fact, the discharge is probably larger, as the basin is small, and the depth of rain greater than belongs to the parallel in general.

If we estimate the mean fall of rain, not for the whole globe, but for the dry land, at $2\frac{6}{10}$ feet, or 31 inches, it will amount to 25,500 cubic miles *per annum*, of which, according to our calculation, the sea receives, by the rivers, about 5100. Of this quantity, the Amazon discharges $\frac{1}{10}$, the Plata $\frac{1}{25}$, the Mississippi $\frac{1}{38}$, the Ganges $\frac{1}{90}$, the Danube $\frac{1}{200}$, and the Thames $\frac{1}{13,000}$ part. The water thus delivered into the ocean, if not counterbalanced by evaporation, would raise the level of the sea two inches in a year. It amounts to $\frac{1}{36,000}$ part of the mass of the ocean, supposing it to have a mean depth of two miles. In other words, the water discharged by the rivers would fill the present bed of the ocean in 56,000 years. We may infer farther, that the greater part of the supply of water belonging to each region circulates between the atmosphere and the earth, suffering a loss of one-fifth every time it falls upon the latter, and receiving an equivalent addition from the vapours of the sea. The smallness of this supplementary portion, compared with the whole quantity, is a circumstance which consists well with the general regularity of the annual supply of moisture, and the stability of the order of the seasons.

Declivity of Rivers.

As very large rivers, with numerous tributary streams, necessarily occupy the lowest situations in all countries, it follows that their courses have a very small declivity. The surface of the Amazons, at Jaen, 3000 miles from the sea, has only an elevation of 194 toises, which gives five inches *per* mile for the mean fall; and over the whole of this space, the navigation of that majestic river is not interrupted by a single cataract. In the last 200 leagues of its course, the inclination is believed not to exceed 11 feet, or $\frac{2}{10}$ of an inch *per* mile. A series of tides, felt to the distance of 600 miles from its mouth, exists in its bed contemporaneously, following one another up the channel, and giving its surface the form of a waving line. The Ganges, reckoning its sinuosities, has only a fall of four inches *per* mile, from Hurdwar, where it leaves the Himalayah chain to the sea. Humboldt thinks the declivity in the lower course of the Mississippi is still smaller. The Wolga, from its source to the Caspian Sea, falls 957 French feet, or about five English inches *per* mile. The Nile, though it falls from a height of 10,400 feet at its head (barometer 22 inches), if Bruce may be believed, has a very small inclination in the lower part of its course. The celebrated cataracts of Syene, which were said by the ancients to produce endemic deafness, consist merely of ten successive steps of six inches each, dispersed over two-thirds of a mile, and which are capable of being passed by boats. There is still one singular phenomenon connected with large rivers, which has been little attended to.

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Their beds, at some places, like the lakes of mountainous regions, have a greater absolute depth than the adjoining seas. In the Amazon, above the Rio Negro, about 1000 miles from its mouth, Condamine found no bottom with a line of 103 fathoms. Now the height of its surface here could not be above 70 fathoms, and its bottom must, therefore, have been at least 100 feet below that of the sea on the coast. At a small distance above New Orleans, where the height of the surface of the Mississippi could not exceed 40 or 50 feet, Mr Darby found the depth to be 153 feet; and hence the bottom must have reached 50 or 60 feet below that of the shallow sea at its mouth. *

Lakes.

Lakes are among those natural objects which contribute, in the highest degree, to the picturesque beauty of the earth's surface. Like the sea, they exercise a beneficial influence on the climate and soil, by moderating the extremes of heat and cold, and by diffusing humid vapours over the land. When they occur in the courses of rivers or at their fountains, they serve as back reservoirs, to equalize the discharge, and to prevent those sudden inundations which are often so destructive. Of all the great natural features of the globe which are subject to mutation, lakes are probably the least permanent. The waste of mountains, and the raising of the bed of the great ocean, are operations of which the effects can scarcely become sensible in millions of years, but in the filling up of lakes, striking changes are often produced within the lifetime of an individual; and within the periods to which history reaches, several have entirely disappeared.

Lakes are chiefly of two kinds; those which are formed in deep hollows between the ridges, or at the foot of mountains, and which are fed by springs or torrents; and those which are formed in low and level countries by the surplus water of rivers, or in consequence of the want of a general declivity in the ground. We have thus two grand systems of lakes in the old continent. The one accompanies the great Alpine girdle, and includes the lakes of the Pyrenees, Alps, Appenines, those of Asia Minor, Syria, and Persia, with the Caspian Sea, the Aral, Balkash, Baikal, and all the series of lakes found at the foot of the Altaic chain. The other begins at the low shores of Holland, and extends along the south-east coast of the Baltic and Gulf of Bothnia, and thence in smaller numbers along the Frozen Ocean to Behring's Straits. Except in central Africa, the regions south of the great mountain band, so far as they are known, contrast remarkably with those of the north, by the fewness of their lakes. A chain of lakes, but generally smaller than the mountain lakes of the old world, accompanies the Andes from their southern extremity, through the isthmus and Mexico, to their northern termination. In the level part of South America, as in the southern regions of the old world, lakes are comparatively rare; and the coincidence is no less striking in the north, where the regions round Hudson's Bay present a multitude of lakes, corresponding in numbers, character, and geographical situation, with those which skirt the shores of the Baltic and Frozen Ocean.

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The Caspian.

The Caspian, which is the largest lake in the world, and has really the character *of an inland sea*, merits particular notice. Its length is 750 miles, breadth about 200; it embraces an area of 170,000 square miles, and receives the waters of a surface about five times as large. Its general depth is 60 or 70 fathoms, but, near the south end, no bottom has been found with a line of 380. It is salt, and, like the ocean, is subject to storms; and, either from the effect of winds, or the unequal discharge of the rivers, it is subject to irregular elevations, varying from four to eight feet. The Caspian is distinguished from all other lakes and seas in the world, by the remarkable lowness of its surface, which was found by Engelhardt and Parrot to be 334 feet beneath that of the Black Sea. The inhabitants, therefore, of Astracan, and other places on its shores, live at a lower level by 200 or 300 feet than any other people on the globe. (Tuckey, *Marit. Geog.* I. 457. *Edin. Phil. Jour.* No. VI. 408.)

Saltness.

Lakes are salt only when they are placed in districts where the soil contains saline matter, and their saltness is invariably greater when they have no efflux. Most of the lakes of Europe are either fresh or slightly saline; but the Caspian Sea, the lakes Aral, Baikal, and others that accompany the Altaic chain, as well as those of Persia, being situated in the midst of plains full of salt, or in regions where salt springs abound, are almost universally impregnated with this mineral. The most highly saline waters known are found in lakes which receive streams but give out none. Thus the lake Ourmiah, in Persia, and the Dead Sea in Judea, receiving continual supplies by the streams from the neighbouring soil, which is every where full of salt, while nothing but fresh water is carried off by evaporation, the mineral accumulates, and their waters are found to contain, in the one case six, and in the other eight times as much salt as those of the ocean. (*Edin. Phil. Jour.* No. IV. 356.) When the quantity carried down by the streams exceeds what the water will hold in solution, the surplus is deposited in beds at the bottom; and hence the numerous layers of salt which are found mixed with thin strata of mud at the bottom of dried up lakes. Large shallow lakes, like that near Teheran, in Persia, which is 150 miles long, often lose their waters in the heat of summer, and become salt marshes, or plains, covered with a salt crust. (Kinneir's *Geog. of Persia*, 117.)

Depth.

The depth of lakes in mountainous districts is often remarkably great. That of Loch Ness, on the line of the Caledonian Canal, is 130 fathoms in some parts, which is four times the mean depth of the German Sea, and its bottom is actually 30 fathoms below the deepest part of that sea between the latitudes of Dover and Inverness. The bottom of the

* Humboldt's *Pers. Nar.* IV. 310, 455, V. 57. *Edin. Phil. Jour.* No. V. 409. Rennell, *Phil. Trans.* 1781. *Histoire Gen. des Voyages, Abr.* XII. p. 330—380.

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Lake of Geneva, at the depth of 161 fathoms, reaches from the high plateau which surrounds it to within 200 feet of the level of the Mediterranean. It is difficult to account for the existence of such deep lakes among mountains whose debris are spread abundantly over countries much lower; but perhaps the profound cavities discovered in the beds of great rivers, like the Amazons, may lead us to suspect that they owe their existence to the agency of debacles, or vast currents of water, at some recent geological period, but anterior to the existence of man.

Temperature.

The temperature of deep lakes presents what we should at first view consider as an anomaly. The heat of the waters at the bottom is never that of the containing solid strata, as we should expect, but in temperate climates always much lower. In Loch Katrine and Loch Lomond, Mr Jardine found the temperature about 41° at all depths below 40 fathoms, while that of the surface was 57° or 59°, and the mean heat of the climate is 47°. The deep waters in the Lakes of Thun and Zug have a temperature of 41° and $41\frac{1}{2}$°, and those of the Lake of Geneva 42°, though the mean heat of the climate is 49°. In the Lake Sabatino, near Rome, where the annual temperature is about 60°, the thermometer indicates $44\frac{1}{2}$ at the depth of 80 fathoms. This apparent anomaly in lakes is accounted for by the physical constitution of water. As this fluid attains its maximum density at 40°, the upper strata, if cooled down to this degree, descend to the bottom; but if heated up ever so high, remain at the top. The cold impressions received at the surface are thus carried below by the internal movement of the water, while the hot impressions can travel down only by the conducting power of the fluid, which is remarkably small. The variable influence of the seasons is little felt below 15 or 20 fathoms, and disappears entirely at 40 fathoms. In all fresh water lakes, exceeding this depth, there must, therefore, be a constant tendency in the inferior waters to approach the temperature of maximum density. To a certain degree this must be controlled by the heat of the strata which form the basin, and this may perhaps account for the slight difference in the temperature of the deep waters in the Italian lakes and those of Swisserland and Scotland. (See the Art. CLIMATE.)

The Ocean.

The ocean, though it presents to the eye only the image of a watery waste, sustains a most important part in the physical economy of the globe. It is the great fountain of those vapours which replenish our lakes and streams, which dispense fertility to the soil, and clothe the surface with all the pomp and pride of luxuriant vegetation. By its salutary action on the atmosphere, it tempers the extremes of opposite seasons and of opposite climates. It affords an inexhaustible supply of animal food, and of salt, a substance of the utmost value to human life. As the great highway of commerce, it connects the most distant parts of the globe, and affords the advantages of free and abundant communication to nations which mountains and deserts seem to have separated from each other. Its shores have been in every age the great seats of civilization; in all the great continents, rudeness and barbarism grow upon us as we advance into the interior; and it requires no great sagacity to discover that the central regions of Asia and Africa, from their want of inland seas like the Mediterranean or Baltic, or navigable rivers like the Amazons, will be the last portions of the habitable globe over which the arts will extend their empire.

The ocean, with all its inland bays and seas, covers an area of 145,600,000 square English miles, or nearly three-fourths of the surface of the globe. About $\frac{7}{12}$ of the great body of waters lie in the southern hemisphere, and $\frac{5}{12}$ in the northern. In the one, the ocean is to the land nearly as 7 to 5, and in the other as 13 to 2. Laplace has calculated that its mean depth is but a small fraction of the difference between the axes of the earth,* which is 25 miles. If, therefore, we suppose the mean depth to be two miles, the cubic contents will be 290,000,000 of cubic miles.

Geographers divide the entire mass of the ocean into five great basins. The Pacific, the largest, separates America from Asia; the Atlantic separates Europe from America; the Indian Ocean separates Asia and its isles from Africa; the Arctic or North Polar basin encompasses the North Pole; and the Antarctic the South.

Pacific.

The Pacific Ocean, 11,000 miles in length from east to west, and 8000 broad, occupies a superficial space rather larger than the whole mass of the dry land. From Cape Horn to the head of the Bay of Bengal a rampart of mountains, containing the highest chains in the world, is arranged round this sea, at a less or greater distance from its shores. But an inner and broken chain extends from Alyaska through the Aleutian Isles and Kamtschata, Japan, the Phillipines, Borneo, Celebes, and New Guinea, to New Holland; and this chain, with the Rocky Mountains and Andes, seem placed on one continued vein of igneous matter, for they include in their wide circle the most numerous and active volcanoes in the world. From the Sea of Otchosk to Cape Horn its coasts are closely girt by the great American and Asiatic chains, which leave only a stripe of low shore, too narrow to admit of deep gulfs or large rivers. But from the Sea of Otchosk southward, the great Asiatic chain recedes from the shores, and opens an extensive country, which inclines to the Pacific. Yet though this basin forms more than one-third of the whole ocean, it certainly does not receive more than one-eighth of the whole river water. On the western side and between the tropics, its surface is studded with innumerable groups of islands, all remarkably small, and consisting generally of coral reefs, rising up like a wall from unknown depths, and emerging but a very little above the

* A determination in more precise terms would have been desirable, but we take the statement as given by Daubuisson (*Geognosie*, I. 35), not having seen the *Memoires of the Institute* for 1818, to which he refers.

sea. These islands are the work of myriads of minute insects, whose incessant labours are thus gradually creating new lands in the bosom of the ocean. On the western side, it communicates with the inland seas of Otchosk and Japan, the Yellow Sea, and the Chinese Sea. These and the inlets of California and Queen Charlotte's Sound we shall not stop to describe. The Pacific Ocean, in consequence of the wide expanse of its surface, is remarkably exempt from storms, except near its mountainous shores, and hence the name. Its small isles, in which the fervid heat of the torrid zone is mitigated by the presence of so vast a body of water, enjoy perhaps the most delicious climate in the world.

Atlantic.

The Atlantic basin extends from 70° of north to 35° and 50° of south latitude. Its length is about 8500 miles; its breadth, which in the latitude of 52° north is 1800 miles, and near the equator 2100, at the northern tropic spreads out to 5400, including the Mexican Gulf. It covers about 25,000,000 square miles, exclusive of inland seas, which is nearly one-half of the extent of the Pacific Ocean. Its southern division does not contain one single deep inlet, nor one island of any magnitude; while its northern division abounds in large islands, and in deep and numerous inland seas on each side, which penetrate far into both continents, and have rendered it the seat of the most extensive commerce in the world. Few large rivers fall into this sea on the east side, but on the west it receives the three largest rivers on the globe, the Plata, Amazon, and Mississippi.

Indian Ocean.

The Indian Ocean extends between 40° south and 25° of north latitude, and from the Cape of Good Hope to Van Dieman's Land. Its length is about 4500 miles, its mean breadth is nearly the same, and it covers a surface of about 17,000,000 of square miles. Its shores are generally mountainous; it contains many islands, two large open bays, those of Bengal and Oman, and two deep inlets, the Persian Gulf, and Red Sea. A particular system of winds, called Monsoons, prevail in the northern part of this basin.

Antarctic.

The Antarctic basin, which surrounds the south pole, joins the Pacific in the latitude of 50°, and the Indian Ocean in the latitude of 40°. It embraces an area of about 30,000,000 of square miles. This sea is generally covered with floating ice as far north as latitude 60°. The appearance of a fixed barrier of ice, filling nearly all the space within the Antarctic circle, has led geographers to infer the existence of a mass of land near the pole, but no land was seen by navigators in a higher latitude than 60°, till the discovery of New South Shetland in 1819. This country lies between 55° and 65° of west longitude, and reaches north to the 62d parallel, but how far it extends southward, and whether it is one large region, or a cluster of islands, is unknown. (See *Edin. Phil. Jour.* No. VI.)

Arctic.

The Arctic basin, or Frozen Ocean, comprises a great part of the space within the 70th parallel. The discoveries of Captain Parry, and the very recent observations of Mr Scoresby in East Greenland have gone far to prove that the tracts of land within this polar zone consists rather of clusters of islands than of a continent. What proportion of the space the sea and land respectively occupy, it is impossible to calculate. Of the many deep gulfs which open into this basin on the north coasts of Europe and Asia, the White Sea is the only one of any importance to navigation. The rest are shut almost constantly by the ice.

Mediterranean.

A detailed description of all the great inland seas would be out of place in this brief sketch; but the Baltic and the Mediterranean, on account of their superior importance, merit a special notice. The Mediterranean, the finest inland sea in the world, is 2350 miles long, from 100 to 650 broad, and with the Adriatic, but exclusive of the Black Sea, embraces an area very nearly of 1,000,000 of square miles. Its depth, which is generally too great to afford soundings, diminishes to 100 fathoms between Sicily and Malta, and to 30 between Malta and Cape Bon in Africa. Placed in the midst of high mountains, its shores are steep and narrow; and, if we exclude the waters of the Nile and the Black Sea, the districts whose rivers it receives do not quite equal its own surface in extent. Adding 500,000 miles for the basin of the Nile, the space which may be called the *river domain* of the Mediterranean, amounts to 1,400,000 square miles. But its inland position gives this sea a proximity to a vast range of country; and, since vapour diffuses itself by its own elasticity, independently of the winds, were each portion of the adjoining land to draw its moisture from the nearest sea, so far as the natural limits of evaporation permit, we may calculate that the vapours of the Mediterranean would be diffused over a space five or six times larger than the basins of its rivers; and that it expends probably three times as much water as it receives. Its surface, depressed by this constant drain, is said to be 34 feet lower than the Red Sea; and hence, powerful currents rush in from the Black Sea by the Dardanelles, and from the Atlantic by the Straits of Gibraltar to restore the level. Its superior saltness is also accounted for by the constant influx of salt water from the ocean, while fresh water only is carried off by evaporation. Like all inland seas, which open to the west, it has no general tides; but local tides are felt, which rise three feet at Venice and at Marsala in Sicily, one foot at Naples, one to two at Toulon, and six inches on the Syrian coast. A current circulates round the line of its coasts, entering the Straits on the south side, setting along the African shore to Syria, where it turns north-westward, and, joined by the current from the Dardanelles, it makes the circuit of the Adriatic, then of the coasts of Tuscany, France, and Spain, and ultimately returns into itself at the Straits. (Tuckey, II. 122, 355.)

Black Sea.

The Black Sea, and Sea of Azoph, are properly inland lakes (like Ontario and Erie), which discharge their surplus waters into the Mediterranean. These two seas occupy a superficial space of 170,000 square miles, and receive the waters of a surface more than five times as large as their own, or about 950,000 square miles. Hence they have a constant efflux: their waters are turbid with floating soil, and so fresh, that ice appears in the bays of the

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Black Sea, and covers the Sea of Azoph for four months every winter, though they are placed under the same parallels with Italy and the south of France. The channel of the Thracian Bosphorus, from 600 to 2000 yards wide, has undoubtedly been excavated by the current, which flows at present with a velocity of from three to five miles an hour; and traces of a connection between the Sea of Azoph and the Caspian exist in the low sandy tract along the course of the Manitch, which abounds in salt lakes, and marine exuviæ. *

Baltic.

The Baltic, 1200 miles long, embraces an area of 175,000 square miles, including the Cattegat. It occupies the bottom of a natural basin, which extends from the Dofrines to the Erzegebirge, and the heights of Valdai, and it receives the waters of a surface nearly five times as large as its own. Hence, like the Black Sea, it has an efflux current, and its waters, which are remarkably fresh, are partially or entirely frozen over, for three or four months in its southern parts, and for five or six in the Gulfs of Bothnia and Finland. The tides advance no farther than the three passages of the Sound, and the Great and Little Belt, which have a breadth of $1\frac{5}{8}$, of 8 and of $\frac{3}{4}$ miles respectively, with a depth varying from 19 to 27 fathoms. The mean depth of the Baltic is 60 fathoms. Its currents, which vary with the state of the winds, and the freshes of the rivers, begin in the Gulfs of Bothnia and Finland, and set outwards on both sides, through the Sound and Belts. At the mouth of the Baltic, as well as that of the Mediterranean, an under current has been suspected to exist in an opposite direction to the upper, and probably smaller in magnitude. The difference of specific gravity between the Atlantic waters and those of these two seas render the existence of the under current credible. (Tuckey, I. 211.)

The other most remarkable inland seas are, in Europe, the North Sea, 160,000 square miles in extent, reaching from Calais to Orkney. Its mean depth is 31 fathoms, its greatest 190. It is deeper at the north than the south end, and at the sides than in the middle, where vast sand-banks cover its bottom. In America, there are, on the west side of the Atlantic, the Gulf of Mexico, 580,000 square miles in extent, whose western shores are remarkably destitute of ports, and are covered by annually increasing sand-banks. Farther north are the Chesapeake Bay, 200 miles long; the Gulf of St Lawrence, shut in by Newfoundland; Hudson's Bay, in the same latitude with the Baltic, but twice as large, and loaded with ice even in summer: Baffin's Bay, almost constantly shut by the ice, communicating, we have reason to think, with the Polar Sea and Hudson's Bay, and surrounded chiefly by large islands.

In the Indian Ocean the only deep inland bays are the Persian Gulf, 600 miles long, with parched sandy shores; and the Red Sea, 1500 miles long, which abounds in coral reefs, and, unlike every other sea in the world, does not receive a single river. It has considerable tides, and, as might be expected, a current inwards from the ocean. It has a particular system of winds, which blow always either up or down its channel. (Tuckey, III. 67, 88.) The inland seas in the Pacific Ocean have already been briefly noticed.

Temperature of Ocean.

The temperature of the ocean, like that of the land, varies with the latitude; but the variations, whether depending on the situation or the season, are less great, less sudden, and less frequent. The diurnal heating power of the sun is spent in the one case on a sheet of water ten or twelve feet in thickness, while, in the other, it does not penetrate more than one or two inches into the land. The mean temperature of the sea at the equator, according to Humboldt, is from 78° 8′ to 81°; it is tolerably uniform for every meridian as far as 28° of latitude; and diminishes at a corresponding rate in both hemispheres as far as the 48th parallel. Beyond this the cold is greater in the southern hemisphere. From the effect of currents, however, and the want of continued registers, it is difficult to state numerically the temperature of each latitude. The recorded observations of navigators exhibit striking anomalies. In general, the temperature of the ocean at the surface does not adapt itself to temporary changes, or to the diurnal variation, but follows the mean monthly temperature of the parallel, without, however, reaching the extreme points to which this temperature goes in the opposite seasons. This may be inferred from the phenomena of insular climates. (Humboldt, *Pers. Nar.* II. p. 50, 65, 87.)

In the ocean, as in lakes, we find the water colder as we descend farther below the surface. This decrease of heat is neither uniform for the same parallel; nor does it bear any constant relation to the depth; nor are its variations capable of being connected with the distance from the equator or the pole. At the depth of 100 fathoms, the difference is sometimes no more than 1°, and sometimes so great as 20°; and this, too, when the heat at the surface was about the mean annual heat for the parallel. Sometimes the coldness attains its maximum at 100 fathoms, and sometimes it increases to 400 or 500. Humboldt thinks that, on a mean, the change is about six times more rapid than in the atmosphere, or about 1° Fahrenheit in 50 feet; but the facts are too anomalous to be easily brought under any general rule. Perhaps they agree best with the supposition that strata of different temperatures and densities, preserving themselves pretty distinct from each other, move slowly in different directions in the inferior waters; while the lowest and coldest, gliding over the unequal bottom, descend to greater depths, or mount nearer the surface, according as the absolute depth of the sea is greater or less. Hence the coldness of the waters on sand-banks and shoals; and hence also the changes produced in the temperature of the sea by storms, which mingle the water of different strata. The law that connects these changes, when rightly understood, may perhaps afford a measure of the depth for parts that cannot be sounded. To the coldness of the inferior strata, however, there is one

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* Tuckey, II. 357. Pallas's *Trav. in South Russia,* I. 78, 490, 506.

remarkable exception. It was ascertained by Mr Scoresby, and is confirmed by the observations made in the late polar expedition, that in the Greenland sea the temperature increases with the depth. The increase of heat does not follow any determinate ratio, being from 1° to 5° in 100 fathoms; but it is constantly progressive, and at the depth of 730 fathoms (lat. 79°, long. 5½° E.), it was found to be 8°. In fact, the bottom waters at Spitzbergen, as Mr Scoresby observes, are from 16° to 20° above the mean temperature of the climate. The most plausible explanation of this anomaly is, that the westerly current from Nova Zembla, rendered specifically light by the fresh water of the great rivers of Northern Asia, may rise above the branch of the Gulf Stream which penetrates to these latitudes; and the warm waters of the latter will thus be found at the bottom. The specific gravities observed by Mr Scoresby, however, do not tend much to confirm this hypothesis.*

Ice. A permanent zone of ice surrounds each pole, the breadth of which varies with the seasons. On the west side of the Atlantic, the extreme point of open sea, in winter, is found on the coast of Greenland at latitude 66° or 67°; but in the longitude of 5° or 6° east, the sea remains open to lat. 76° or 79°. In summer navigators have penetrated along the margin of Baffin's Bay as high as 77°, on the coast of Spitzbergen to 81°, and at Behring's Straits to 71°. In the southern hemisphere the utmost point to which Cook was able to penetrate was 71° in summer; but navigation was very difficult beyond the parallel of 60°; floating ice overspread the sea nearly as far as 50°, and detached icebergs are carried by currents in both hemispheres as low as 40°. (Cook's *Voyages*. Scoresby, I. 262.) In a general point of view, the ice-bound seas and lands are nearly conterminous with the arctic circle in the north hemisphere, and with the parallel of 60° in the south. In the one case they occupy about one-twelfth, and in the other about one-seventh of the hemisphere.

Saltness. The saltness of the sea is affected by currents, storms, heavy rains, the discharge of rivers, and by evaporation. Hence there is often little consistency in detached observations, but the results upon the great scale agree with theory. According to the experiments of Dr Marcet, the mean specific gravity of the main ocean is 1,02777. The Southern Ocean, which receives a less proportion of river water, is salter than the northern. Inland seas, like the Baltic, Black Sea, and White Sea, which receive more rain water than they expend in vapour, and have an efflux current, are fresher than the ocean. On the other hand, the Mediterranean, which is a sort of natural saltern, from which the waters of the Atlantic, poured in with their salt, are drawn off fresh by evaporation, contains more saline matter than the main ocean. We may infer from theory, that the same thing holds true of the Red Sea. There is no proof that the sea is salter under certain meridians, or at certain depths, than at others; but in general, the sea is saltest where it is deepest and most remote from land. Salt water parts with its salt on freezing, and hence the dissolution of ice freshens the sea. The following are some of Dr Marcet's results:

	Sp. Grav.		Sp. Grav.
Arctic Ocean, -	1.02664	Black Sea,	1.01418
North Hemisphere,	1.02829	Baltic, -	1.01523
South do.	1.02882	White Sea,	1.01901
Mediterranean, -	1.02930		

(*Ed. Phil. Jour.* No. IV. 356.)

Tides. The tides are periodical oscillations in the waters of the ocean, which take place twice every twenty-four hours, and are produced by the attraction of the moon and the sun. In the open sea, they are at their height three hours after the moon has passed the meridian of the place, and the meridian opposite. They are smallest towards the poles, and greatest at the equator, where, however, they do not exceed two or three feet in the great ocean. Their greatest elevation takes place in narrow seas, where the action of the moon is aided by winds, currents, the position of the coast, &c. The highest tides known are in the Gulf of St Malo, where the flood, driven back by the coast of England, rises to the height of seven or eight fathoms. Inland seas, whose entrances face the west, have rarely any tides, because the moon acts on all their parts at once, and there are no lateral waters to flow in and produce a local elevation. (Tuckey, I. 34.)

Currents. Independently of the motion of the tides, the waters of the ocean are found to be scarcely anywhere stationary. Local or temporary currents are produced by winds, the discharge of rivers, the fusion of fields of ice, the evaporation of inland seas, and other causes. But, exclusive of these, which we shall not attempt to describe, there are certain permanent and general currents, which are supposed all to originate in two great movements,—that of the tropical waters westward round the globe, and that of the polar waters towards the equator. The movement of the tropical waters westward is ascribed to the agency of the trade winds, which, blowing constantly in one direction, must impress their own motion on the sea to a certain extent. But the resulting current is necessarily modified by the position of the great continents. The motion of the polar waters towards the equator is not so well accounted for, nor perhaps is its general existence so well ascertained. It is supposed, that the copious evaporation at the equator, reducing the level of the sea there, the more elevated waters of the polar regions flow in to supply the loss; and, farther, that the fusion of ice in these seas must produce an accumulation of water, which naturally seeks a level by moving to the equator. But it is reasonable to believe, that the loss of the equatorial seas by evaporation is balanced by the greater fall of rain; and if the melting of ice

* Forster's *Observations*, p. 60. Scoresby, *Account of Arctic Regions*, I. 187–210. *Edin. Phil. Jour.* No. XI. 165. Humboldt, *Pers. Nar.* II. 56. Dr J. Davy, *Phil. Trans.* 1817.

produce a current from the pole during one season, the congelation of the water should produce an opposite current during another.

Gulf Stream.

The great tropical current which flows round the globe prevails generally between 30° north and south of the equator, and has a mean velocity, according to Humboldt, of nine or ten miles a day. In the Atlantic, it separates into two branches, one of which constitutes the well known Gulf Stream. This branch flows northward, through the middle of the Atlantic, till it reaches the Cape Verd Islands; it then turns west, passes through the Caribbean Sea and the strait between Cuba and Yucatan, winds round the Mexican Gulf, and rushes out by the Bahama Channel; then, spreading out to a greater breadth, it sweeps along the shores of the United States to Newfoundland. At this point it is deflected south-eastward by a southerly current from Baffin's Bay, and, passing the Azores and Canary Isles, returns into itself, and repeats its circumgyration. The waters of the North Atlantic between 11° and 43° thus form a continued whirlpool, performing a circuit of 3800 leagues in about thirty-four months. Its velocity is inversely as its breadth. In the Bahama Channel, its breadth is fifteen leagues, and velocity from three to five miles an hour. In its retrograde course, from longitude 50° to the Azores, its breadth is 160 leagues, and velocity seven or eight miles a day. A zone of motionless water, 140 leagues broad, separates the direct and retrograde courses. This great current sends off one branch near Newfoundland, which proceeds north-eastward, and sometimes deposits tropical fruits on the shores of the British Isles and Norway. A second branch, escaping at the Azores, enters the Straits of Gibraltar. The Gulf Stream preserves a temperature of 71° in the latitude of Boston, while that of the neighbouring waters is 63.5. It is not improbable that the westerly part of this current, involving by accident in its course the canoes of the early inhabitants of Western Africa or the Canary Isles, has hurried them to the coast of Caraccas, and thus been one means of transplanting the human race from the Old World to the New. (Humboldt, *Pers. Nar.* I. 46—60.)

The other branch of the great tropical current is supposed to set along the coast of Brazil and double Cape Horn. In the Pacific Ocean, a general current, westward, is said to carry the waters away from the coast of Peru. It is less perceptible on the west side, till it enters the Indian Ocean, when strengthened by the northerly currents there, it flows along the eastern coast of Africa, and round the Cape in a rapid stream, 130 miles broad, and 7° or 8° warmer than the contiguous waters. A current from the South Pole sets along the west side of New Holland into the Bay of Bengal. It is supposed that other portions of the general polar current deflect the great westerly current northward, after it has passed the southern promontories of Africa and America.*

Greenland Current.

In the North Atlantic, in the space comprised between Greenland and the coasts of Britain and Norway, and between Labrador and Spitzbergen, a great body of waters, acted upon by three or four lateral currents, is supposed to perform a perpetual revolution. These waters receive their impulse eastward from a branch of the Gulf Stream, which passes from Newfoundland along the north-west coasts of Scotland and Norway. At the North Cape, a great westerly current from Nova Zembla turns the waters north-westward, along both sides of Spitzbergen. Beyond this island, being met by a current from the Pole, they turn south-westward, and pass along the coast of Greenland to Davis' Straits, where they are deflected southward by a fourth current from Baffin's Bay, and at the Bank of Newfoundland recommence their revolution. Thus two great whirlpools, connected with one another, touching at the Bank of Newfoundland (which seems to be a bar cast up by their conflicting waters), and revolving in opposite directions, occupy four-fifths of the North Atlantic. The small current which sets from the Bay of Biscay across the mouth of the English Channel, and through the Channel of St George, is most probably a branch of the Gulf Stream which parts from the revolving current about the Azores. It is reasonable to believe, that great vortices of the same description will be found in the other parts of the ocean, when they have been as minutely examined as the North Atlantic. (Scoresby, I. 206.)

Climate.

The value of any part of the earth's surface to man depends not merely on its extent, position, and soil, but also on its climate, which regulates the nature and variety of its productions, the degree of its fertility, and, to a certain extent, its salubrity, and its capacities of improvement. With no essential superiority but that of climate, the small island of Ireland supports, and probably will always support, a greater number of inhabitants than the whole northern section of the plain of Siberia beyond the 60th parallel.

The climate of a country is chiefly influenced by its distance from the equator, and its elevation above the level of the sea. But it is affected in a smaller degree by the nature of the surface, the abundance or scarcity of humidity, the proximity or remoteness of the sea, of lakes, of mountains, of arid or frozen plains, and perhaps also by the internal heat of the earth.

Mean Temperature of Globe.

The mean temperature of the earth at the equator, which is pretty uniform under every meridian, is estimated, by Humboldt, at 81°.5 of Fahrenheit's scale. The decrease of heat, as we recede from the equator, on either side, follows different laws in the two hemispheres, and in the same hemisphere under different meridians. On the west coast of Europe, about the meridians of London and Paris, the cold increases much more slowly upon us as we go northward from the equator, than in any other part of the world. In North America, at the meridian of 80° or 90° west from London, and in Asia at the same distance east, the increase of cold is much more ra-

* Varenius's *Gen. Geog.* Chap. XIV. Tuckey, I. 43. Dr J. Davy, *Phil. Trans.* 1817.

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pid as we approach the pole. In the northern hemisphere, generally the cold is greatest on the east side of both the old and new continents, and least on the west. Humboldt has generalised this fact, and inferred, that all continents and large islands are warmer on the west side than the east. The following table, extracted from Humboldt's admirable Essay, exhibits the different gradations of the mean annual temperature in Western Europe and North America, continuing the scale to the equator.

Mean Annual Temperature.

Lat.	Old World.	New World.	Diff.
0	81°.5	81°.5	0
20	77 .9	77 .9	0
30	70 .7	67 .1	3.6
40	63 .5	54 .5	9.
50	50 .9	38 .3	12.6
60	41 .0	25 .0	16.
70	33 .0	0*.0	33

We have few observations for the east coast of Asia; but the following shows that the climate of this region approaches to that of Eastern America rather than Western Europe.

Europe.		Asia.		America.	
Naples, Lat. 41	Temp. 63.3	Pekin, Lat. 40	Temp. 54.8	Philadelphia, Lat. 40	Temp. 53.4

Thus the mean annual temperature of North America is 9° lower than that of Western Europe at the latitude of 40°, 16° lower at lat. 60°, and 33° lower at lat. 70°; a similar difference obtains between the climates of Western Europe and Eastern Asia. By comparing places under the same parallel, we find that this change is not sudden, but progressive. Petersburg, on the same parallel with Upsal, is 3° colder, and Moscow is 5° colder than Copenhagen. The annual temperature of West Greenland in lat. 70°, which is 17° or 18°, according to Sir C. Gieseké, is very nearly the mean between that of the North Cape and Melville Island, as its intermediate situation would lead us to expect.—(*Edin. Phil. Jour.* No. IX. 201.) These differences are rendered more sensible when we connect the places having the same annual temperature by lines, which Humboldt has named isothermal lines. Thus the isothermal line of 59° (Fahrenheit) passes along the latitude of 43° in Europe, but descends to lat. 36° in America. The isothermal line of 41° passes from the latitude of 60° in Europe, to that of 48° in America, showing that the same annual temperature which is found at the 60th parallel on the eastern side of the Atlantic, is only found at 12° farther south on its western shores. The western coast of North America again is warmer than the east; and hence if we were to trace the isothermal lines round the northern hemisphere, they would all have concave summits at the east sides of Asia and America, and convex summits at the west sides of America and Europe.

Summer and Winter.

The difference of mean temperature between summer and winter (reckoning each to consist of three months) is nothing at the equator, and constantly increases as we approach the pole, as shown in the following table:

	Latitude.	Mean Temperature.		Difference.
		Of Winter.	Of Summer.	
Algiers,	37°	61°.5	80°.2	18°.7
Buda,	47½	34 .0	70 .5	26 .5
Upsal,	60	25 .0	60 .2	35 .2

The extreme difference of the seasons is smaller under the warm meridians of Western Europe than any where else, and seems to be greatest where the mean annual temperature is lowest,—near the east coasts of Asia and America.

Places on the Same Parallel.

	Latitude.	Winter.	Summer.	Difference.
Copenhagen,	55½°	30°.7	62°.6	31°.9
Moscow,	55½	10 .8	67 .1	56 .3
Rome,	42	45 .8	75 .2	29 .4
Pekin,	40	26 .4	82 .6	56 .2
New York,	41	29 .8	79 .2	49 .4

Places having the Same Mean Annual Temperature.

	Mean An. Temp.	Winter.	Summer.	Difference.
St Malo,	54°	42°.3	66°.0	23°.7
New York,	54°	29 .8	79 .2	49 .4

If we draw a line on the map in a north-east direction from Bourdeaux to Warsaw, and continue it till it strike the Wolga in latitude 55°, all the places situated under this line, at the same elevation, will have nearly the same summer temperature of 69° or 70° of Fahrenheit's scale. The lines of equal winter temperature decline in an opposite direction, and deviate much farther from the plane of the parallels. Thus a straight line drawn from Edinburgh to Milan, almost exactly at right angles to the line of equal summer temperatures, would pass over places, all of which, if equally elevated, would have nearly the same winter temperature of 37° or 38°. The other lines of equal summer and winter temperatures have a direction corresponding to these, but not exactly parallel.

* Deduced by interpolation from the temperature of Natchez, Cincinnati, Churchill Fort, and Melville Island, reckoning that of Melville Island—2 Fahrenheit.

On comparing the climate of the two hemispheres, we find that the southern is rather colder than the northern, but is more remarkably distinguished by the greater equality of its seasons. This last effect may obviously be referred to the influence of a greater surface of sea upon a smaller extent of land. In the southern hemisphere also, the temperature seems more uniform under different meridians. At Port Jackson, Buenos Ayres, and the Cape, all nearly under one parallel, the annual mean temperature is almost exactly the same.

Effect of Elevation.

The second general cause that affects the temperature of places is their elevation above the level of the sea. The following table, by Humboldt, shows that the ratio of decreasing temperature, as we ascend in the atmosphere, is not the same at different latitudes, nor is it uniform at the same place for equal successive altitudes.

Height in English feet.	Equatorial Zone from 0° to 10°.		Temperate Zone from 45° to 47°.	
	Mean Temp.	Difference.	Mean Temp.	Difference.
0	81.5	0	53.6	0
3195	71.2	10.3	41.0	12.6
6392	65.1	6.1	31.6	9.4
9587	57.7	7.4	23.4	8.2
12792	44.6	13.1		
15965	34.7	9.9		

This table shows, that, at the equator, the thermometer sinks 10° in the first thousand yards of ascent, or 1° for 310 feet. In the next thousand yards it sinks no more than 6°, or 1° for 524 feet. In the third and fourth stages, there is a remarkable acceleration. In the whole column of air to the limit of perpetual snow, at 15,965 feet of elevation, the decrease is 1° for 341 feet. Humboldt ascribes the smaller rate of decrease in the second and third stages to the large clouds chiefly suspended in this region, which intercept the radiant heat of the earth. In the temperate zone the atmospheric cold increases more rapidly. The decrease of heat for the first thousand yards is at the rate of 1° for 253 feet, but to the limit of perpetual snow (at a temperature not of 32°, but of 23°.3) it is 1° for 317 feet, or, in round number, 1° for 100 yards. Observations made, however, in the free regions of the air, may give different results from those which were made on the sides or summits of mountains. But generally in the temperate zone, of two adjacent places, if the one is 1000 yards higher than the other, it will have a climate 12° colder. For smaller heights the decrease is proportional. In the upper regions of the atmosphere, the difference between the heat of night and day, summer and winter, is smaller than at the surface of the earth. This law of decrease explains to us the extreme cold felt in the elevated plains of Siberia, and the mild temperature enjoyed in the torrid zone, on the table land of Mexico, the plateau of Pastos, and other high lands. Humboldt calculates, that in the temperate zone, every hundred metres of ascent (110 yards) diminishes the heat as much as a change of 1° of latitude.

Local Temperature.

The temperature of countries is affected by the proximity of the sea, and the nature of the adjacent land. The extremes of temperature are always comparatively little felt in small islands, remote from continents. In the United States intense cold is experienced as often as the wind blows from the frozen plains round Hudson's Bay. (Warden's *America*, I. 154.) From high mountains, gusts of cold wind, called *snow winds* by mariners, rush down and cool the circumjacent plains. (Volney's *Trav. in Syria*, I. 340.) At Calabozzo, in Venezuela, the temperature, which was from 87° to 90° in March, rose to 104° or 105°, whenever the wind blew from the parched and dusty surface of the Llanos, or great plains. (Humboldt, *Pers. Nar.* IV. 325.) The heat accumulates to an astonishing degree, when the wind passes over extensive deserts of fine and almost impalpable sand, which rises in the air, and hangs over the surface like a fog, or mounts in whirling columns to a great height, mixing its burning particles with the mass of the atmosphere, and communicating to it an intolerable heat. (Kinneir's *Geog. Mem. of Persia*, 216, 222.) In Europe, where the proximity of the sea cools every part of the surface by the agency of the winds, the accumulation of heat never proceeds so far as in Asia and Africa. Even in low plains, sheltered on the north, the temperature scarcely ever exceeds 100°; but at Bagdad and at Bushire, where the south wind arrives, heated by the burning sands of Arabia, the thermometer sometimes stands at 120° or 125°; and on the west coast of Africa, where similar causes operate, it is said to rise to 130°.* Though the mean annual temperature is highest at the equator, the extreme summer heat, so far as it proceeds directly from the solar action, is greatest at the tropic, and is even rather greater at the latitude of 45° than at the equator. (Art. CLIMATE, in this *Supplement*, p. 182, Table.) We may therefore conjecture that the hottest summer climate in the world is to be found in the western parts of the Sahara of Africa, under the northern tropic, where the winds blow over a zone of sandy plains 4000 miles in breadth, unbroken by any considerable mountains, or by any surface of water

* Morier's *Journey*, II. 97. *Edin. Phil. Jour.* No. V. 197. Tuckey, II. 442. Humboldt repeatedly observed the temperature of the soil in Equinoctial America at the hottest time of the day. It varied with the nature of the mineral substance. The highest he has recorded, we think, was that of a coarse granitic sand at Magpures, whose temperature at two P. M. was 140°.5. That of a fine granitic sand at the same place was 126°.5; of a granitic rock, 117°.6. We may hence conclude, that the air, though perfectly stagnant, could in no possible circumstances be heated above 140°, and this only within two or three feet of the ground. Humboldt's *Pers. Nar.* V. 165.

except the narrow inlet of the Red Sea. At the same time, it is possible that a much narrower surface than this may suffice to communicate the maximum effect of the solar heat to the atmosphere, and the actual heat generated may depend more upon the nature of the surface and its low elevation, than upon its extent.

It appears that within the tropics seas have very little effect in tempering the accumulating heat of the land, when situated to the westward of a continent, but a great effect when situated to the eastward. In the *steppes* of Caraccas, which are open to the sea on the east, the heat rarely exceeds 99°, but even in the wooded regions of Senegambia and Guinea, much nearer the coast, it rises to 130°. * In the temperate zones, on the other hand, it is clear that the sea exerts its influence in a direction precisely contrary. When the land lies to the eastward, the sea mitigates the extremes of heat and cold very much; when to the westward very little. This is abundantly proved by the difference of temperature already noticed between the east and west coasts of the two continents. Now, the sea can exert very little influence over the temperature of the land, except through the agency of the atmospheric currents; and the phenomena in both cases seem to be accounted for by the prevailing direction of the winds. Within the tropics, these are almost constantly from the east; but from the tropics to the latitude of 60° north (and probably much farther), the prevailing winds are from the west. † Within the torrid zone, therefore, we should expect to find the extreme summer heat constantly accumulating from the east side of continents and islands to the west; but in the temperate zones, the extremes both of heat and cold will as regularly increase from the west to the east. This is found to be the case, and whatever other causes may be conjoined with those now assigned, there can be no doubt that the latter have really a great influence.

Internal Heat of the Globe.

The temperature of each zone has such a correspondence with the amount of the solar impressions, as to lead to the inference, that the heat of the globe is entirely derived from the sun; and Professor Leslie has calculated, that, upon this hypothesis, the mean heat of the interior ought to be 66°.8. Humboldt has ascertained, however, that, in latitudes above 45°, the mean heat of springs and caves generally exceeds that of the atmosphere. The difference, which amounts to 6° or 7° at the parallel of 70°, he ascribes to the covering of snow in the higher latitudes, which prevents the loss of heat during the winter months by radiation, or the contact of cold winds. But there are facts which indicate that this heat may be derived from another source. To say nothing of volcanoes, we have hot springs in all parts of the world, at all temperatures below boiling water; and evidence still less equivocal is afforded by the high temperature of deep mines. The following are examples:

At Giromagny, in the Vosges, annual temperature at surface, 49°; at 110 yards depth, 53°.6; at 336 yards, 65°.8; at 472 yards, 74°.6.

In Saxony, in four of the deepest mines, annual temperature at surface, 46°.4; at 170 to 200 yards depth, 54°.5; at 280 yards, 58°; at 360 yards, 62°.6. (Daubuisson, *Geog.* I. 444.)

In the coal mine of Killingworth, the deepest in Britain, annual temperature at surface, 48°; at 300 yards, 70°; at 400 yards, 77°. In seven others of the deepest coal mines in Britain, a corresponding gradation was observed. (Mr Bald, *Edinb. Phil. Jour.* No. I. 134.)

Rate of Increase.

In these British mines, the increment of temperature is about 1° for 15 yards of descent. In the Vosges, it is about 1° for 20 yards, and in Saxony, 1° for 22 yards. Taking 20 yards as a mean, if the increase follows the same arithmetical ratio to a considerable depth, we should find the temperature of the Bath waters (116°) at 1320 yards below the surface, and that of boiling water at 3300 yards, or nearly two miles. The frequency of hot springs from 80° to 120°, the rarity of those that approach the boiling point, and the constancy of temperature in them all, are circumstances remarkably consistent with this hypothesis. The facts, if they do not establish, at least strongly support three conclusions; 1st, That the heat of the interior of the earth is always greater than at the surface; 2d, That this heat augments progressively as we descend, in a ratio bearing some relation to the depth; 3d, That, even at moderate depths, this heat is greater than the mean heat of the globe ought to be, if entirely derived from the sun. Such an interior heat, if it exists, must be constantly diffusing itself towards the surface; and at the surface it may be kept down, so as to affect the temperature derived from the solar action very feebly, by the greater or less rapidity of its dissipation. But as it is very improbable that it should be diffused with perfect equality round the whole exterior shell of the globe, it may be the true source of some of those anomalies of climate (such as the discrepancy in the annual heat under the same parallel) which cannot be easily referred to other known causes. ‡

The Atmosphere.

The atmosphere is an elastic fluid which surrounds the globe on all sides, and serves the most important purposes in the economy of nature. It sustains the life of an immense variety of organic beings, spreads the moisture of the ocean over the land in fertilizing showers, receives, dissipates, or decomposes, the innumerable mephitic vapours which are continually exhaled from the surface; and is the grand agent

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* Humboldt, *Pers. Nar.* IV. 315. Tuckey, II. 442, 444.

† Cotte, *Recherches sur les Vents Dominans, Journal de Physique,* Tom. XXXIX. p. 267.

‡ As nearly the whole of the preceding view of climate has been taken from Humboldt's excellent *Essay on Isothermal Lines, and the Distribution of Heat over the Globe,* particular references were not thought necessary. The English translation, given in the *Edinburgh Philosophical Journal,* No. 5—9, has been consulted.

which, by its incessant motion, tempers the extremes of heat and cold, and enables man to support himself in every climate from the equator to the vicinity of the pole.

The fluid which forms the atmosphere consists of two gaseous substances, oxygen and nitrogen, united by a weak affinity, in the proportion of 21 parts of the former to 79 of the latter. The vital functions of animals and plants depend chiefly on the presence of oxygen, though nitrogen also enters into their composition. With these two are intermixed a very small quantity of carbonic acid gas; a variable portion of aqueous vapour, and in the highest regions of the atmosphere, where meteors are common, hydrogen has been supposed to exist. Air from the tropics and the polar regions, from the most healthy and the most insalubrious countries, exhibits no sensible difference in its constituent parts. A hundred cubic inches of air at the surface of the sea, when the thermometer is at 60°, weigh $30\frac{1}{2}$ grains. The whole atmosphere is equal in weight to a sheet of mercury, 30 inches, or to a sheet of water, 34 feet deep, and were its density every where the same as at the surface, would reach no higher than 27,000 feet, or five miles. But its extreme elasticity causes the upper strata to expand indefinitely, and the phenomenon of meteors show that it exists in a state of extreme attenuation, at a height a hundred times greater than this. Considering the incessant currents which agitate its whole mass, there is a surprising uniformity in its pressure. The annual range of the barometer, which indicates the variation of the pressure, does not exceed from $\frac{1}{8}$ to $\frac{1}{2}$ inch in the torrid zone; is about two inches at Liverpool, the same at Petersburg, and was found by Captain Parry to be $1\frac{8}{10}$ inches at Melville Island in one year.* The extreme variation, which no where exceeds $3\frac{1}{2}$ inches, is not greater than one-ninth part of the total pressure. It is greater in the temperate zone than at the equator or the pole, and in winter than in summer. The density of the air decreases in a geometrical ratio as we ascend, and in temperate climates is diminished to one-half at an elevation of $3\frac{1}{2}$ miles. We are hence enabled to measure heights by the variations of the barometrical column. Changes in the atmospheric pressure, when they are great, have been observed to take place simultaneously at Edinburgh, Paris, and Geneva, and must, therefore, affect a great range of country at the same time.

Winds. The unequal distribution of heat over the surface of the land and water necessarily disturbs the equilibrium of the atmosphere, and produces currents of air, or winds. These currents, however various, have been supposed to result from two general movements, pervading the whole mass of the atmosphere. The heavy and cold air of the polar and temperate regions having a tendency to displace the warm and rarified air of the torrid zone, generates a current in each hemisphere towards the equator. To replace the air abstracted from the higher latitudes, an upper and counter current flows back from the equator to the pole; and thus the atmosphere, while it performs a constant revolution, tempers the extremes of climate, by transporting the cold of the frigid zone to the equator, and carrying back the heat of the equator to the frigid zone. These great south and north currents, which are to be considered as the *primary* winds, receive various modifications. The under current, which proceeds from the polar regions, having impressed upon it the slow rotary motion of these regions, does not acquire in its journey the velocity of the parts it passes over. Instead, therefore, of proceeding directly along the meridian, it is deflected to the westward. It pursues this lateral course more and more as it approaches the torrid zone, and the impulse south and north being destroyed when the currents from the opposite hemisphere meet at the equator, the motion westward alone remains. This constitutes the well known trade wind, which blows from the east at the equator, from the north-east at the northern tropic, and the south-east at the southern. The upper and counter current again, carrying with it the rapid velocity of the equatorial regions, does not travel right along the meridian, but deviates more and more to the east as it advances; and when its progress towards the pole is stopped by the accumulation of air from the opposite meridians, the motion eastward alone remains, and it settles into a west wind. Thus a constant east wind should prevail at the equator, and a constant west wind near the poles; but the latter, being primarily an upper current, may not be invariably felt as a west wind at the surface. It does not follow, however, that the upper and under currents preserve their relative situation over all the temperate zone. From the greater accumulation of air in the higher latitudes, and from variations of temperature produced by local causes, the upper current will often be bent down to the surface, and the lower current ascend. This interchange will take place occasionally at all parts of the temperate zone. Hence, in high latitudes, storms of wind, which mingle the warm upper current with the cold air below, always produce an increase of heat, as Captain Parry found.—(*Voyage*, p. 118.) In the northern hemisphere, then, when the cold current from the pole sweeps the surface rapidly, we have a *north* wind; it becomes a *north-east* wind when its motion southward is retarded; an *east* wind when it is checked, and a *south-east* when it is deflected back, by mingling with a current from the south; all of which, except the last, are generally found to be cold winds. When the warm current from the south descends and sweeps the surface, we have a *south* wind if its motion northward is rapid; a *south-west* when its motion northward is retarded; a *west* wind when it is checked; and a *north-west* when it meets and mingles with a current from the north. All these, except the last, are generally warm winds, as experience proves. The line of division between the upper and lower cur-

* *Manch. Mem.* IV. 534. *Edinb. Trans.* II. 213. Parry's *Voyage*, 269.

rents should be where the mercury stands at 15 inches, which is at the height of $3\frac{1}{2}$ miles. This should be the region of clouds; and clouds do generally approach to this elevation.

Trade Winds.

This theory, upon the whole, agrees tolerably well with the facts. But the variable surface and temperature of the land greatly affect the course and velocity of the winds. In the torrid zone, within the parallel of 25° or 30°, on each side of the equator, the trade winds blow constantly from the east. From the superior warmth of the northern hemisphere, the line that separates the opposite trade winds is not the equator, but the 2d or 3d parallel north. To a certain extent, also, they follow the course of the sun, reaching a little further into the south hemisphere, and contracting their limits in the north when the sun is on the south side of the equator, and making a reverse change when he declines to the north. In a zone of variable breadth in the middle of this tract, calms and rains prevail, caused, probably, by the mingling and ascending of the opposite aerial currents. High lands change or interrupt the course of the trade winds. Thus, under the lee of the African shore, calms and variable winds prevail near the Cape Verd Islands, while an eddy or counter current of air from the south-west is generated under the coast of Guinea. The lofty barrier of the Andes shelters the sea on the Peruvian shores from the trade winds, which are not felt till a ship has sailed 80 leagues to the westward; but the intervening space is occupied by a wind from the south. In the Indian Ocean the trade wind is curiously modified by the lands which surround it on the north, east, and west. The southern trade wind blows regularly from the east and south-east, from 10° of south latitude to the tropic, but in the space from 10° south latitude to the equator, north-west winds blow during our winter (from October to April), and south-west in the other six months; while, in the whole space north of the equator, south-west winds blow during summer, and north-east during winter. The cause of these remarkable winds, which are called monsoons, has not been very satisfactorily ascertained. (Varenius's *Gen. Geog.* Chap. xxi.)

Variable Winds.

The region of constant winds is confined within the 30th parallel on each side of the equator. On the outer side of these limits, calms prevail pretty generally over a narrow space, beyond which the region of variable winds extends to the pole. In the open sea, where the true direction of the winds is best known, navigators have repeatedly observed that throughout this region the prevailing wind is from the west. Mr Forster observes, that beyond the tropics, the west winds are the most universal. That east winds have an ascendancy within the Antarctic circle, as he thinks, may be questioned; few observations having been made there, and those few not to be depended on, in consequence of the local influence of the ice. (*Observations*, p. 127, *et seq.*) According to the author of Lord Anson's voyage, "a westerly wind almost perpetually prevails in the southern parts of the Pacific Ocean" (he speaks of latitude 60°), and a similar wind in the northern parts carried the Spanish galeons from Japan to California, along the parallel of 35° or 40°. (Book I. Chap. ix. II. Chap. x.) West winds prevail in Kamchatka; they blow three-fourths of the year in Hudson's Bay; the west and north-west winds predominate greatly at Melville Island; and it is a familiar fact among mariners, that, by means of these winds, the voyage eastward across the North Atlantic is generally accomplished in about half the time of the voyage westward. (Scoresby, I. 411. Parry, *Voyage*, 299.) On the west coast of Europe, too, the west and south-west winds are the most general. It is remarked also, that in our climate, south and south-east winds are the most rare; that winds between north and east are almost invariably cold; those between south and west warm; and those between north and west of a mixed character. So far the facts correspond generally with the theory, though many anomalous circumstances may be found.

Local Winds.

The change of the seasons which affects the local temperature so much, necessarily influences the atmospheric currents. Accordingly, the most violent tempests are about the equinoxes, and in every country there are prevailing winds peculiar to certain seasons. It may be suspected that most of the winds observed on land or in confined seas are merely local eddies, or reflex currents, produced by the irregularities of the surface. Thus, while the south-west wind prevails almost one-half of the year at Dover, London, and in the west of England generally, it is scarcely felt at Liverpool, which lies in the gorge of a valley, where the western chain of hills is interrupted; and on the other hand, the south-east, so uncommon in the rest of England, is the predominating wind here. (*Manch. Trans.* IV. 601, 615.) In the long basin of the Red Sea, the wind blows in no direction but right up or down. In Lancaster Sound, Captain Parry found the wind to blow always either east or west. For ten months of the year a wind (which is probably a smaller branch of the north trade wind) blows constantly up the valleys of the Mississippi and Ohio, preserving a breadth in the latter of twelve or fifteen miles. (Tuckey, III. 70. Warden's *Amer.* I. 155.) In the list of *Vents Dominans* for the interior of Europe, collected by Cotte, nothing like a system can be discovered—nothing but local currents running in every possible direction, according to the position of mountains and valleys. Winds, indeed, even when strong, are often confined to a space surprisingly small. In the temperate, but still more in the frigid zone, two or three winds are often seen blowing from, or to, different points within a few leagues; nay, of two ships within sight of one another, one is sometimes becalmed, while the other is seen struggling with a storm. In the northern seas even strong gales, when they have carried a ship into frozen water, invariably desert her, or give place to a wind which blows from the ice. The effect can only be attributed to the comparative coldness of the ice, and warmth of the water, generating a local descending current over the one, and an ascending current over the other. (Scoresby, I. 403—409.)

The Mediterranean has a system of winds peculiar to itself, which we have not room to explain. All warm countries, where sandy deserts abound, give birth to pernicious hot winds. Such is the Si-

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moom or hot wind of the desert, and the Sirocco, so well known in the east, and along the shores of the Mediterranean. For the description of these, as well as the sea and land breezes, and other peculiar winds, we refer to the Article METEOROLOGY.

Rain.

Rain, so essential to the fertility of the soil, is very unequally distributed to the different regions of the globe. Nature has arranged it so, that the supply of the atmospheric moisture is most abundant in those latitudes where evaporation is most rapid. Or rather the processes of precipitation and evaporation, depending partly on the same principles, and exerting a reciprocal influence, tend to adjust themselves to each other, though this tendency is perpetually disturbed by local causes. Rain is produced by the mixture of atmospheric currents of different temperatures. The power of air to hold water in solution does not increase in the same ratio with the increase of its temperature, but in a much higher ratio. Hence, when two masses of air, saturated with moisture, and of different temperatures, are mixed, the resulting compound is not capable of holding the whole water in solution, and a part of it is precipitated in rain. As the whole atmosphere when saturated is calculated not to hold in solution more water than would form a sheet of 5 inches in depth, while the mean annual deposit of rain and dew is probably 35 or 40 inches, it is obvious that the supply of atmospheric humidity must be many times renewed in the course of a year. The quantity of rain at any place is affected chiefly by three circumstances. It is greater at the equator than towards the poles,—at the sea coast than in the interior,—and on mountains or high grounds than on plains. The winds, too, exert a certain influence, which, at any particular place, depends on their temperature, and on their travelling to that place over a dry or a humid surface. Where so many causes interfere, whose effects are scarcely capable of estimation, it would be difficult to determine the depth of rain proper to each parallel, even were our observations more numerous and accurate than they are. In a former part of this article we gave as an approximation 83 inches for the equator, and 8 inches for the pole. We have since found the following estimate by Humboldt, to whose authority we readily defer in every question of this kind. Except within the tropics, it corresponds generally with that which we gave.

Lat.	Eng. Inches.	Lat.	Eng. Inches.
0°	96	45°	29
19	80	60	17

Rain at Sea-Coast.

Since the supply of humidity is greatest in the vicinity of the sea, the rains must be generally more abundant there than in the interior. On the other hand, we know that currents of air fraught with vapour move with great rapidity, and that the atmosphere is far from needing an entirely new supply from the ocean after each precipitation, because three-fourths probably of the rain that falls soon rises again into the air, and continues thus to circulate between the clouds and the earth. These circumstances lead us to conclude, that the difference in the annual depth of rain, between inland places and those on the coast, is not so great as might be imagined. We find, accordingly, that a small increase of elevation compensates for a great distance from the sea. Thus 29½ inches of rain fall at Puy at the sources of the Loire, while 24½ only fall at the sea-port of Rochelle near its mouth, and at Geneva the depth is 40 French inches, while at Paris, 300 miles nearer the sea, it is no more than 19½. If we compare Toulouse, Paris, and Gottingen, inland places not far from the coast, with Buda and Prague, places in the heart of Europe, and, like the others, not much elevated, the mean fall of rain at the three former is 20.4 French inches, at the two latter 14.1. (Cotte, *Jour. de Phys.* T. XXXIX.) These facts are cited to support the idea of a decreasing scale of rain, rather than to mark the ratio of decrease. The latter is a problem for which we are yet unprovided with data. We may infer from theory, that the decrements, so far as they are affected by mere distance, will form a geometrical series. If the atmosphere, for instance, loses one-third of its moisture in the first 400 miles from the sea, it will lose one-third of what remains in the next 400; and so on.

Rain in Mountains.

The elevation of the land has a much more marked effect on the quantity of rain than its distance from the sea. Mountains precipitate the humidity of the atmosphere, not so much by attracting it to their summits, as in consequence of their rocky or grassy sides, when acted upon by the sun, heating large masses of air in the cold upper regions of the atmosphere. These warm masses of air, which abstract moisture from the aerial columns around them, stream upwards and mingle with the cold strata above, or come into contact with cold currents moving laterally, or suffer sudden and partial changes of temperature from the vicissitudes of night and day, and thus incessantly generate the circumstances which cause precipitation. It is evident that snow-clad mountains, from the constancy of their temperature, will serve much less perfectly than those whose sides are bare as nuclei for precipitating the atmospheric humidity; and that, in temperate climes, the rains will be more abundant on all mountains in summer than in winter. Along the shores of the Adriatic, and in the valley of Lombardy, the annual fall of rain is from 26 to 35 French inches; but in the Carnic and Julian Alps, it amounts to 100 inches. From the effect of this great barrier in intercepting the aqueous vapour, and producing desiccation, Feltre, on the east side of the first chain, has one-half more rain than Trent, which is higher, but on the west side; and Coire in the Grisons, 1900 feet above the sea, has less rain than the champaign cities of Vicenza and Verona. (Cotte's *Tables.*) In England it is found that Keswick and Kendal, situated among the mountains, have 67 and 59 inches of rain respectively, while places in the level interior country and on the sea-coast have only about 24 inches. But though more rain falls in mountainous than level countries, the depth is greater at the bottom of a mountain than at the top, and close to the surface of the ground than at any distance above it, in all cases.

Rain in Torrid Zone.

In the torrid zone, a small thick rain falls every day on that side of the equator on which the sun is,

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but generally intermits during the night. When it ceases in the one hemisphere, it commences in the other, and is nearly perpetual in a zone of two or three degrees in breadth, which separates the two systems. When the rains begin, the heat increases, and the trade wind subsides. Yet, even in the torrid zone, there are tracts where rain seldom or never falls, such as the Sahara of Africa, the low coasts of Caraccas, and the desert shore of Peru, between 15° and 30° of south latitude. In many parts there are two wet and two dry seasons in the year; and in some regions, from the effect of mountain ranges and peculiar winds, places under the same parallel have their wet and dry seasons at opposite periods.* Though the annual depth of rain is greatest within the tropics, the number of rainy days follows an inverse order, and diminishes as we advance from high latitudes to the torrid zone. According to Cotte, the mean number of rainy days from 12° to 43° of latitude is 78, while it is 161 from latitude 51° to 60°. More rain falls in summer than winter in all latitudes, but in the temperate zones the rains of winter are more frequent than those of summer, though less in quantity. (Cotte, *ubi supra.*)

Mr Dalton reckons the annual deposit of water in England to be 31 inches of rain, and five of dew. His estimate is perhaps rather high. The distribution of the rain through the different seasons is so much affected by local circumstances, that it is difficult to ascertain the mean result. In general, the fall seems to be least in spring, and greatest in autumn, and less in the six winter months than in the summer. The following table affords an interesting view of the connection between the phenomena of wind and rain in this country. It gives, for one year (1775), the number of days each wind prevailed at London; the quantity of rain that fell during the prevalence of that wind; and the humidity of the winds, or the relative quantity of moisture which each would deposit in the same space of time.

Winds.	Days.	Rain.	Humidity.	Winds.	Days.	Rain.	Humidity.
N.	22½	0.327	11	N.W.	39½	2.391	48
S.	21½	0.251	9	S.E.	32½	0.944	22
E.	11	0.168	12	N.E.	72	2.148	23
W.	18½	1.907	82	S.W.	148	18.975	100

The whole quantity of rain for that year was 27,11 inches; of which it will be observed that two-thirds fell with the south-west wind. The prevailing winds are the south-west and north-east, the primary winds of our hemisphere. The least frequent are the east and west. The south and north winds are the driest, and the south-west and west the most humid, as might be expected. †

Geographical Distribution of Plants.

The geographical distribution of plants is a subject of such extent, that our narrow limits compel us to dismiss it with a few general remarks, extracted from Humboldt's *Prolegomena de Distributione Geographica Plantarum.* Each plant has generally a determinate climate, to which it is best adapted; there are other climates, however, in which it can be raised, though less advantageously; but beyond certain limits it either ceases to grow altogether, or is supplanted by other plants better adapted to the situation. Since vertical elevation has the same effect on climate as distance from the equator, there are properly no plants which are peculiar to the frigid zone, because the mountains of the torrid zone, embracing between their base and their summits every variety of climate, either produce, or are capable of producing, all the vegetables of the temperate and polar regions. Plants are absolutely most numerous, and exhibit the greatest variety of species, and the most luxuriant growth, within the tropics, where nature has supplied most abundantly the heat and humidity which contribute chiefly to the developement of their vital functions. They diminish in number, variety, and magnitude, as we recede from the tropics; and in Greenland, Spitzbergen, and the plains of Northern Russia, the wealth of the vegetable kingdom has shrunk to a very small number of mosses and stunted shrubs. The lines that limit the growth of certain plants depend on the average summer temperature, for plants which require a long and moderate heat; on the temperature of the warmest month for those which require a short but great heat; and on the temperature of the coldest month, for those which are unable to resist a considerable cold. Their growth is affected also by the foggy or serene state of the atmosphere, because the direct stimulus of the solar light is as essential to the success of many plants as a certain determinate temperature. Instead of losing ourselves in the labyrinths of general botany, we shall illustrate these principles by a few facts drawn from the history of cultivated plants.

Climates of Cultivated Plants.

The plantain (*Platano harton*), which furnishes a primary article of food in tropical America, requires a mean annual heat from 82° to 73°, and its proper climate is therefore from the equator to the 27th parallel. In the equinoctial zone (lat. 0°—10°) its fruit does not ripen at a greater altitude than 500 toises (534 fathoms). The sugar cane (*Saccharum officinarum*), which has nearly the same range, thrives where the mean annual temperature is from 82° to 73°, and is cultivated, but with less advantage, in the old world to the latitude of 36½°, where the annual temperature is about 67°. In North America, it is cultivated as far as latitude 31°, beyond which it does not succeed, for, though the summer heat is sufficient to ripen its produce as far as 35° or 40°, the rigour of the winter destroys the plant. It succeeds on the table land of Mexico, at the altitude of 900 toises. The cotton plant (*gossypium*) has its favourite climate between latitude 0° and 34°, where

* Humboldt, *Pers. Nar.* IV. 398—410; V. 248. M'Fait's *New System of Gen. Geog.* 153—197.
† *Manch. Trans.* IV. 570—593, V. 346. Horsley, *Phil. Trans. Abridged*, XIV. 44.

the annual heat is from 82° to 68°. But it succeeds wherever, with a mean summer heat of 73° or 75°, that of winter is not below 4 ° or 48°. It is cultivated as high as latitude 37° in America, beyond latitude 40° in Europe, and grows at Astrakan in Western Asia, latitude 46°. (Storch, *Tableau de la Russie*, II. 250.) The date palm (*phœnix*) thrives best between latitude 29° and 35°, but on the shores of Italy, in places sheltered from the north winds, it is cultivated as far as latitude 44°. The citron (*citrus*) has nearly the same range, and is cultivated at Nice in spots 150 toises high. This tree, with the sweet orange, grows in Lousiana, under latitude 30°, but above that it is injured by the frosts. (Darby's *Louisiana*, p. 151.) The olive (*olea*) ranges in Europe between latitude 36° and 44½°. It succeeds wherever with a mean annual heat from 66° to 58°, that of summer is not below 71°, nor that of the coldest month below 42°. This last condition excludes all the North American continent beyond latitude 34°, though the olive thrives 10½° farther north in Europe. The vine (*vitis*) thrives where the mean annual heat is from 62° to 50°, or even 47°.5, providing that of winter is not below 33°, nor that of summer below 66° or 68°. These conditions are fulfilled on the sea-coast of Europe as high as latitude 47°, in the interior as high as latitude 50°, and in North America only as high as latitude 40°. But the favourite climate of the vine in the *Old Continent* is between latitude 36° and 48°, where it yields a generous and excellent wine. The *Cerealia* (wheat, rye, barley, and oats), so important to civilized life, yield profitable returns in places where the mean annual temperature descends to 28°, providing that of summer rises to 52° or 53°. In Lapland, barley comes to maturity whenever the mean temperature of the summer months rises to 47° or 48°. Barley and oats, from the rapidity with which they germinate and ripen, adapt themselves to the short summers of the north, and are found along with the potatoe as high as latitude 69½° in Lapland. In Eastern Russia, upon the Lena (longitude 120°), grain of any kind refuses to grow beyond latitude 60°. (Sauer, p. 24, 137.) Wheat, which is a precarious crop, and little cultivated beyond latitude 58° in Western Europe, yields good returns at this part of the temperate zone, when the mean heat of the seven months from March to October is 55°; but if it is no more than 46°, neither this grain, nor barley, oats, or rye, come to maturity. The *Cerealia* generally, which succeed only in low grounds beyond latitude 60° in Europe, are cultivated to the height of 550 toises on the sides of the Alps in latitude 46°; to the height of 1020 toises (barley and oats) on Caucasus in latitude 42°; and on the sides of the Andes, under the equator, the proper climate of the Cerealia is found between 700 and 1600 toises of elevation (4480 and 10,240 feet). *Maize* accompanies the vine in the west of Europe, but extends farther north on the east. It is most extensively cultivated in its native soil, the New World, where it forms the chief nourishment of man and domestic animals from La Plata to the Canadian lakes. Coming to maturity in four or five months from the time it is sown, and requiring a short but hot summer, it is admirably adapted to the climate of America. There are few situations under the latitude of 45° where it will not grow, but the parallel of 35° is that to which it is best adapted. (Darby's *Louisiana*, p. 138, 144.) The oak ceases to grow beyond latitude 63° in Norway: it terminates at 60° or 61° in Finland; and at 57½° in the government of Perm. The *Pinus sylvester* (Scots pine) reaches the height of 60 feet at the latitude of 70° in Lapland, and grows in situations 125 toises above the sea. The *Betula alba* is found under the same parallel at 250 toises of elevation. In the eastern parts of Asiatic Russia trees are very thin beyond latitude 65°; the larch, pine, birch, and mountain ash, disappear about 66° or 68°; willow and birch bushes, eight inches high, are found as far as 69°. At Hudson's Bay trees of all kinds terminate about latitude 60°. (Sauer's *Account*, &c. 70—91. Mackenzie's *Voyage*, p. 404.)

Range of each Plant.

Let us now endeavour to make a general summary of these details, confining our view to the great continents merely, without regard to the islands. The *plantain* or *banana* we find occupies a zone of 54° in breadth on either side of the equator, which embraces about four-fifths of Africa, one-sixth of Asia, and one-third of America, and excludes the whole of Europe. The climate of the *sugar-cane*, allowing it to extend to 30° on each side of the equator in the New World, and 35° or 36° in the Old, includes the whole of Africa, nearly one-third of Asia, and two-fifths of America, and only touches Europe at its southern extremity. The climate of the *olive* consists of two zones on the opposite sides of the equator, extending from latitude 35° to 44° in the old continent, and embracing very little of the new; this tree being equally injured by the excessive heat of the tropical, and the excessive cold of the extra tropical regions in America.* The *vine* grows as far north as 50° or even 52°, but its profitable culture in Europe does not extend much beyond 48°. In Asia it succeeds at Astrakan latitude 46°, in Bucharia, and at Hami in Chinese Tartary, latitude 43°.† It, therefore, extends, we may suppose, to lat. 45° in Asia generally, Except in islands, or elevated plains, it is probable there are few palatable wines made at a lower latitude than 30°. The vine may hence be considered as occupying a zone of 15° in breadth on each side of the equator (from 30° to 45°) in the Old World, and two corresponding zones of 10° in breadth in the New (from 30° to 40°). These zones embrace about one-sixth of America, one-third of Europe, two-sevenths of Asia, and one-tenth of

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* If Humboldt has accurately defined the temperature for the year, and the coldest month proper for this tree, there ought to be no part of North, and perhaps few parts of South America, where it will thrive. It has not been introduced into the territories of the United States.—Darby's *Louisiana*, p. 150.

† *Topographie des Vignobles*, 489, Paris, 1816. Pallas's *Travels*, II. 430.

Africa. Of the productions which serve for the ordinary sustenance of man, maize and the potatoe have the widest range. The culture of the *potatoe*, as Humboldt observes, extends from the extremity of Africa to Labrador, Iceland, and Lapland. *Maize* bears any natural temperature, however high, and the only circumstance essential to its successful culture seems to be a mean summer heat, not below 68° or 70°. In consequence of this advantage, its climate embraces the whole of the torrid zone, and reaches probably to lat. 48° in America, to 50°, or 52°, in Europe, and 48° in Eastern Asia. It hence includes about five-eighths of America, three-sevenths of Europe, the whole of Africa, and three-fifths of Asia. The *Cerealia* do not succeed in the torrid zone in low situations. The climate adapted to their culture, which begins about lat. 30°, extends to lat. 50° in America, to 70° in Lapland, 62° in Finland, and 60° throughout the north of Russia, generally including five-sixths of Europe, three-fifths of Asia, one-tenth of Africa, and one-fourth of America. The region of *forests*, or the climates adapted to the growth of wood, embraces the whole of the Old and New World, except a narrow zone on the north border of each, which includes one-tenth of America, one-tenth of Europe, and one-tenth of Asia. As the prolific powers of the soil depend chiefly on the stimulus of heat and moisture, it is reasonable to believe with Humboldt, that the general fertility of the earth increases as we approach the equator. (*Pers. Nar.* IV. 106.) In warm countries, the produce not only bears a much higher proportion to the seed, but the husbandman has the advantage generally of two harvests in one year. We may probably assume, then, without any great error, that, with regard to plants which grow both in the warm and temperate zones, the productiveness of the soil increases in the ratio of the annual temperature, and the depth of rain; and that for countries under the same parallels, it is generally in proportion to the duration and intensity of the summer heat. The cosine of the latitude, or the distance from the axis, as it expresses pretty nearly the proportions of heat and moisture for each parallel, may therefore be taken as an approximate measure of the relative fertility. But when we take into view the superior productiveness of vegetables which are peculiar to warm regions, such as maize, rice, and the banana, there can be no doubt that the power of the soil to sustain animal life, augments in a much higher ratio than the cosine of the latitude, and that at the equator it is at least ten times as great as at the latitude of 60° in Europe. It is scarcely necessary to qualify those statements by saying, that we speak solely of low and level regions, and of ordinary soils. There are warm valleys in the north, where the productions of southern climes will grow beyond the limits we have assigned; there are elevated tracts in the torrid zone where every plant found in cold countries can be raised; and in all the zones, there are deserts and rocks which bid defiance to the vivifying power of the sun, and the genial influence of the seasons.

Population of the World.

The number of human beings upon the globe has been variously estimated. A thousand millions have been mentioned, apparently for no other reason than the convenience of a round number. M. Malte-Brun, a late and very respectable authority, reduces the amount to 650,000,000. We think his enumeration for Asia, Africa, and America, still rather high, and without detailing the grounds of our judgment, or pretending to accuracy, where any thing better than loose approximations is unattainable, we submit the following estimate as the result of our inquiries.

Europe, ...	185,000,000
Asia (with Australia and Polynesia),	270,000,000
Africa, ...	55,000,000
America, ...	40,000,000
	550,000,000

Varieties of Human Species.

The diversity of colour, stature, form, physiognomical expression (and we may add language), among different portions of the human race, have at all times arrested attention; and have in many cases created, and in all inflamed, those feelings and prejudices which have made nations the enemies of each other. Philosophers have endeavoured to analyse and class the characters which produce these diversities; and since migrations and conquests have blended the distinctive peculiarities of different races, they have attempted to ascertain those primary types, from the combination of which all the other varieties have arisen. We have no room to discuss the many idle and fantastic hypotheses which have been built upon this subject, but shall merely give a brief outline of the system of the learned Blumenbach, who has prosecuted the inquiry with the aid of a profound knowledge of physiology. This philosopher has resolved the varieties of the human species into five primary classes,—the Caucasian, Mongolian, Ethiopian, American, and Malay. In the *Caucasian* race the skin is white, the cheeks red (a character scarcely found in any other race), the hair brown, running into yellow and black, soft, long, and undulating; the head symmetrical, and rather globular, the forehead moderately expanded, the cheek-bones narrow, not prominent, the face oval, the nose narrow and slightly aquiline, the lips gently turned out, the chin full and round, the facial angle large. This variety comprehends all the Europeans except the Finns, Samoieds, and Laplanders; the Western Asiatics, as far as the Oby and the Ganges, and the people of North Africa. In the *Mongolian* variety, the skin is olive, the hair black, straight, and stiff, the head almost square, the cheek-bones prominent outwards, the face broad and flat, and its parts less distinct than in the Caucasian race, the eye-brows little arched, and the space between them flat, the nose small and flat, the aperture of the eye-lids narrow. This includes the remaining Asiatics (except the Malays), the Finns, Samoieds, Laplanders, Greenlanders, and Esquimaux. In the *Ethiopian* race, the skin is black, the hair black and crisp, the head compressed laterally, the forehead receding, the cheek-bones standing much forward, the nose flat, and blending with the cheeks, the lips thick, the chin rather receding, the jaws lengthened forwards, and the under part of the face prominent. This includes all the African nations, except those of the Caucasian race in the north.

In the *American* race, the skin is of a copper colour, the hair black, stiff, and straight, the forehead short, the cheek-bones and face broad, the orbits and eyes deep, the nose rather flat, but still prominent. In this are included all the American tribes except the Esquimaux. In the *Malay* race, the skin is tawny, the hair black, soft, curled, thick, and abundant, the head rather narrow, the forehead slightly arched, the parietal bones prominent, but not the cheek-bones, the nose full, broad, and bottle-shaped at the point, the mouth large, the face projecting forward in the lower part, but the features viewed in profile, more distinct than in the Ethiopian race. This variety comprehends the inhabitants of Malacca, the Marian, Philippine, Molucca, and Sunda Isles, and Polynesia. It is to be observed, that it is only in some particular tribes, or portions of each race, that its characteristics are strongly marked. None of the leading varieties are absolutely pure, and all of them may be found passing into each other by insensible gradations, from the effects of mixture.

The question has been long agitated, whether all the existing varieties have sprung from one parent stock. The arguments in favour of the affirmative appear to us to preponderate. 1. All the different races are capable of uniting with each other, and begetting offspring, which continue themselves by procreation. This is held by naturalists to be one of the most decisive tests of identity of species. 2. There is no essential difference of structure in the various races. None of them have permanently a bone, a blood-vessel, or an organ of any kind, which the others want. There are no differences analogous to those of the stag and the roebuck, or the one and the two humped camel, which clearly mark a diversity of race. 3. The differences which do exist among mankind at large, such as those of complexion, stature, physiognomy, and mental capacity are analogous to those which manifest themselves in one tribe, or nation, and even in one family. We have, therefore, only to suppose that the causes which produce these minor and accidental differences are rendered general and permanent in their operation, by peculiarities of food, climate, or habits, to account for the stronger and more lasting distinctions among nations. This view of the subject is farther confirmed by the changes which climate, food, and different modes of treatment, produce upon domestic animals. 4. The affinities of language, which promise to throw much light on this subject when fully developed, have already afforded presumptive proofs of a common origin in the case of nations whom physiologists class under distinct races.*

(B. B. B.)

PHYSIOLOGY.

Physiology divisible into two Departments.

PHYSIOLOGY, or the study of the phenomena of life, differs from all the other branches of philosophical inquiry, by its involving the consideration of the *final* as well as the *physical* causes of these phenomena. A new principle of arrangement is thus introduced, which is scarcely ever applicable in the sciences relating to the properties of inert and inorganic matter. Those sciences are formed by applying to the subjects they concern, the rules of philosophical induction. By comparing together phenomena, and uniting in one class such as are of the same kind, we arrive at the knowledge of a certain number of general facts, which we regard as laws of nature, and from which, when once established, we deduce the explanation of a multitude of subordinate phenomena, resulting from the simple or the combined operation of these laws. By a series of experiments we succeed in removing all extraneous circumstances, and in reducing each class of phenomena to its simplest conditions; and we are also enabled to vary the combinations, so as to compare the results with the appearances presented to us by nature. But the application of the same methods to the physiology of animal or vegetable life is attended with peculiar difficulty. The immense number of species of living beings, the variety and complexity of the appearances they exhibit, and the extended chains of connection that pervade every part of organic nature, are strikingly contrasted with the simplicity, the constancy, and the uniformity of operation of those physical forces which regulate the changes occurring in the inorganic world. The extensive generalizations which have been so successfully accomplished in the sciences of natural philosophy and chemistry, can be effected only in a very limited degree among the diversified phenomena which constitute the science of physiology; and we have, accordingly, made but very imperfect approaches to the knowledge of those laws to which they are ultimately reducible. The resources of experimental inquiry are here extremely narrowed, in consequence of the close connections which subsist among the powers concerned, and which preclude us from any opportunity of studying them in a separate or isolated state, and of ascertaining distinctly their respective operations.

Study of Functions.

Amidst these obstacles which impede our progress in the direct but thorny avenues to science, we naturally turn to the more alluring, though circuitous paths, which open upon us on every side, in the contemplation of the final purposes of the changes we are examining. So strongly is the character of design impressed upon all the phenomena of organic beings, that we are irresistibly led to associate the views suggested by their relative subserviency to particular purposes, with the more strictly philosophical relation of cause and effect, by which they may also be connected. The relation of means to an end be-

* See J. F. Blumenbach, *De Generis Humani Varietate Nativa Dissertatio*, 1795, 8vo, and Prichard's *Researches into the Physical History of Man.*

comes thus a leading principle of association among the phenomena presented to us by living beings: it gives to the science a new aspect, and creates an interest of a different, and even superior kind to that which mere physical relations are calculated to inspire. The study of the *functions* of life, that is, of the purposes to which the actions constituting life are subservient, is generally regarded, indeed, as the principal object of physiology; and all the facts relating to it are distributed according as they tend to the accomplishment of these purposes. Dazzled by the brilliancy of these objects, physiologists have often lost sight of the essential distinction which subsists between these, and the more sober purposes of philosophical inquiry. In framing theories to explain the phenomena of life, they have most frequently satisfied themselves with pointing out their final causes, that is, the objects which are answered in the economy: and as the detection of this final cause often required the exertion of considerable sagacity, the inquiry has terminated here, and it has not been perceived that the physical theory was left in as great obscurity as before. This proneness to substitute final for physical causes has been the source of frequent delusion, by insensibly leading us to believe that we are really in possession of the physical law on which the phenomenon in question is dependant, when we have merely given it a name with reference to the intelligent agency, by which it was adjusted to its object. In our eagerness to grasp at this kind of knowledge, we have too often mistaken the shadow for the substance.

Final, mistaken for Physical Causes.

The writings of the older physiologists exhibit continual instances of this confusion of ideas. Thus the notion of an *archæus*, or *anima*, entertained by Van Helmont and Stahl, that is, of a presiding spirit, to the operation of which were referred all the vital actions, although, perhaps, naturally suggesting itself to the mind, was yet evidently an unphilosophical assumption, incompetent to explain the phenomena in question, and occasionally even at variance with those very phenomena. The *vis medicatrix naturæ*, to which Hoffman and Cullen so frequently appeal in their pathological reasonings, and which supplied them with ready solutions for every obscure morbid change that embarrassed them, was, in fact, nothing more than a branch of the same doctrine. Nor have the more sober theorists of modern times been sufficiently on their guard against this illusion. In the attributes which John Hunter ascribes to his vital principle, we may continually trace the same want of discrimination between that intelligence, by which the conditions of animated nature were originally adjusted to a variety of contingent circumstances, and those physical laws and agents, by the instrumentality of which the intended objects are attained. When it is said, for instance, in the language of this school, that the coagulation of the blood is occasioned by "the stimulus of necessity," it is clearly the final cause only, and not the physical cause of this phenomenon that is assigned: and it is also evident that no advance is thereby made towards the discovery of the latter. In like manner, the principle of life is represented to us as a new power, with which organized beings are endowed; a power which modifies and controls the operation of those simpler physical laws, to which the same matter, in its unorganized state, is subjected; a power which imposes new cohesive forces on the materials of the solid structures of the body, which imparts to the fluids a new property of coagulation, which alters the order of chemical affinities between their elements, retaining them, contrary to their natural tendencies, in a certain state of equilibrium, and resisting the agency of several causes tending to destroy it; and which, lastly, produces, in a degree somewhat corresponding to the wants of the system, either an evolution or an absorption of caloric. All these, it must be acknowledged, are purposes of manifest utility; being directly conducive to the welfare of the individual, and indeed essential to its continuance in the living state. As means conducive to a specific end, the reference of all these phenomena to the same class is unobjectionable. The fallacy lies in regarding it as a philosophical generalization of effects, of a similar kind, indicative of the operation of a simple power in nature. Between many of the effects in question, considered as physical phenomena, there exists not even the remotest analogy. But it is the fundamental principle of the method of induction that similar effects alone are to be ascribed to the agency of the same principle. Judging from the observed effects, therefore, which differ much from each other, as well as from other phenomena in nature, we ought to infer the agency of several distinct principles, the concurrence of which is required to produce all the complex phenomena of life. We are unavoidably led, no doubt, to view these phenomena as conjoined, because we readily perceive that they tend to the same object, the preservation and welfare of the beings to which they relate. But the unity of design is an attribute of intellect alone, and does not necessarily imply the unity of the agent employed in their production. However natural it may be to conceive the existence of a simple principle of life, and however possible it is, that this hypothesis may ultimately be established as the true one by future discoveries, we should recollect, that, in the present state of our knowledge, it is a mere fiction of the mind, not countenanced by the phenomena themselves, in which we see so much diversity, and, therefore, not admissible as the result of a truly philosophical induction.

Bichât, who was impressed with the necessity of drawing certain lines of distinction among the powers of life, has yet perplexed his system, by taking final causes as the basis of his divisions; a principle which is incompatible with a philosophical analysis of those powers. Thus, the distinction which he labours to establish, between the muscular contractility of animal life, and that of organic life, is founded, not upon any real difference in the nature of the power concerned; for, as we shall endeavour to show in the sequel, the power which resides in the muscles of the voluntary and of the involuntary motions is in all cases the same; but upon a difference in the application that is made of this power in the economy. Dumas has been guilty of a still more palpable error, in thinking it necessary to add to his catalogue of principles, consisting of the acknowledged powers of sensibility and contractility, a third power, which he terms *force de resistance vitale;* thus as-

sociating a final cause in the same rank with causes that are strictly physical. To multiply examples of this mistake would be endless; for it pervades almost every physiological system that has yet been framed.

Design of this Article.

As a full account has already been given, under the head of PHYSIOLOGY, in the *Encyclopædia,* of the principal facts relating to the *functions* of the animal economy, which, as we have stated, are commonly regarded as the leading objects of that study, we shall, in this article, present an outline of what may be considered the *philosophical* department of the science, by attempting an analysis of the principal laws, or ultimate facts to which the vital phenomena are reducible. Setting aside, then, all consideration of functions, we shall examine the changes that occur in the living system, simply as physical phenomena; and we shall endeavour to class them according as they agree or differ among themselves, without reference to the purposes which they may happen to serve in the animal economy. Thus, if we take as an example, the phenomena of the circulation of the blood, which, when viewed with relation to the function, form together so beautiful and harmonious a system, we find that, considered abstractedly, these phenomena are ultimately resolvable into such as result from a few general powers, as muscular contractility, membranous elasticity, the hydraulic properties of the blood, &c. If a similar analysis were made of the phenomena of digestion, we should find them to be the effects of the combined agencies of the muscular action of the stomach and intestines, of the chemical properties of the gastric juice, the bile, &c. of the organic powers of secretion, and so forth; all of which concur in the production of a definite object, namely the conversion of the aliment into chyle. The processes subservient to this object constitute the function of digestion.

These analytical investigations have not been prosecuted by physiologists with the attention their importance deserves. Our knowledge of the principles of the science has, however, been considerably increased by the experimental inquiries that have recently been instituted both in this country and on the continent; and we shall therefore avail ourselves of the present period, as affording peculiar advantages for taking a comprehensive review of the facts which bear upon these questions, and for deducing consequences that may throw considerable light upon the animal economy, and the theory of diseases.

Classification of the Vital Powers.

Of the changes which occur in the living system, some are easily referable to particular classes; others, again, having a less distinct character, are generalized with greater difficulty. Some of the powers concerned in the phenomena of life may be recognized as being identical with those which produce changes in inanimate matter, while the rest are powers peculiar to the living state. Thus the cohesion, elasticity, and tenacity of the particles of the solids of the body; the strength, resistance, &c. of the materials which compose them; and the hydrostatic and hydraulic laws of its fluids, are principles upon which we may safely reason in their application to the mechanism of the living system. Many of the laws of chemistry are also applicable to its phenomena. From our knowledge of these principles we may predict the effects which will, under given circumstances, ensue: and if experience, in any case, teaches us that the result is different, we may thence infer the operation of new causes, peculiar to the living state, and constituting other classes of phenomena.

Analysis of these Powers into,—

The powers comprehended under this latter division have usually been described as reducible to two species, namely contractility and sensibility; for it was supposed that all the phenomena might be arranged under these two heads. We shall endeavour to show that their analysis is incomplete, and to point out at least four distinct principles of which the operation may be recognized in the living body: these are Muscular Contractility, Nervous Agency, Sensorial Power, and Organic Affinity. Let us first, however, fix the meaning of these terms.

1. Muscular Contractility.

Muscular contractility is a power too well known by its effects to require any elaborate definition or illustration in this place. It consists in that property by which, in consequence of the impression of certain agents, the extremities of muscular fibres are made to approach each other, with a force greatly superior to the ordinary mechanical sources of motion.

2. Nervous Agency.

By the term *nervous agency* we would be understood to mean that power which resides in the nervous system, and by which certain effects, hereafter to be described, and which for the present we shall call *impressions,* made on one part of that system of organs, are immediately succeeded by certain other effects at a remote part of the same system. The application of an irritating substance, for example, to one extremity of a nerve, will excite, in one case, muscular contraction; in another case, sensation; in a third, secretion; in a fourth, it will raise the temperature; while, in other instances, it will produce changes of vascular action, and lead to an alteration of the organic structure of parts. Since this propagation of impressions is a fact not exactly analogous to any other phenomenon in nature, we must regard it as the effect of a distinct power, concurring with the rest in producing the general result which we term life.

3. Sensorial Power.

Another power, perfectly distinct from the former, although it also resides in a portion of the nervous system, is that from which the corporeal operations connected with sensation and volition result. Dr Wilson Philip, to whom we are indebted for having clearly pointed out this distinction, has given to this property the name of *sensorial power.* As the term seems to be sufficiently appropriate, we shall adopt it as the designation of this specific property of the nervous system. Dr Darwin had employed the same term in a more extended sense, as including the power of muscular contraction. It should be remembered that it is here limited to those physiological changes in which the mind is immediately concerned.

4. Organic Affinities.

The admission of the powers already enumerated do not yet supply us with the means of explaining a variety of phenomena exhibited by the living system, and which are sufficiently analogous in their nature to warrant our classing them together as depending upon the operation of a common principle. The phenomena in question are those of secretion and

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nutrition, including those of the growth, extension, and modelling of the various organic structures which compose the animal fabric. The powers by which these effects are produced exist in the vegetable as well as the animal kingdom, and appear to result from that particular arrangement of parts which is termed *organization*. These powers, when considered abstractedly from the purposes they serve in the economy, we shall denominate the *organic affinities*, by way of contradistinction from the ordinary chemical affinities to which they are so frequently opposed.

I. We shall first examine the Mechanical Properties of animal structures.

Organization of Animal Membrane.

The basis of the organic texture of the different parts of the body is a peculiar substance, which, amidst its various modifications of cellular tissue, membrane, vessels, neurilema, visceral parenchyma, &c. may be recognized as essentially the same. The term *membrane*, which is applied more especially to a condensed lamina of this substance, may be conveniently extended to the rest, and employed as the generic term for the whole. It has been disputed whether this substance was ultimately resolvable into plates or fibres, and the microscope has been appealed to in support of both opinions; but after all that has been said about the primordial animal fibre, which was stated by Haller to bear the same relation to anatomy which a line does to geometry, the whole may possibly be more the fruit of imagination than the sober account of the real fact. Fontana had viewed it as an assemblage of cylindric fibres, which were twisted and interlaced with each other; but Monro has shown that he was deceived by an optical illusion, to which the incautious use of the microscope frequently gives rise. Bichat describes its intimate structure as composed both of filaments and of laminæ, variously intermixed; and hazards a conjecture that the former are exhalent and absorbent vessels. Bordeu appears to have been the first who advanced the opinion of the homogeneous nature of the cellular tissue, which he compares to froth or glue. Quesnay considered it more as a fluid than as an organized solid. Wolff rejects entirely the idea of its being cellular, and regards it as a homogeneous and glutinous substance, without organization. Blumenbach, Platner, and Meckel, have adopted these views; a statement of the arguments in favour of which is given by Béclard in his *Additions à l'Anatomie Générale de Bichat*. The subject has already been noticed under the head of Anatomy in this *Supplement*. Whatever weight may be allowed to the arguments in favour of the cellular tissue being a homogeneous substance, it seems, from other considerations, more reasonable to suppose that the mechanical structure of all animal substances is framed, even in the simplest cases, with a greater degree of complication than we shall ever have the means of fully ascertaining.

Its Mechanical Properties.

Although ignorant of the arrangement of particles which constitutes the organization of animal membrane, we observe certain mechanical properties to result from it, analogous, it is true, to those that are met with in several inorganic substances, but in general much superior to them in degree. These are flexibility, extensibility, and elasticity. These properties, in their different degrees, are variously combined and modified in the different forms of animal substance, but exist more or less in every organ. As it is not our object to enter into any consideration of the functions to which these properties are subservient, we shall abstain from any remarks on the utility of these properties, but confine ourselves to their physical relations. In this respect, one very striking circumstance requires to be pointed out, namely, that the force of elasticity among the particles composing these animal structures is rarely found in a state of neutrality, but is kept in equilibrium by the mechanical circumstances of situation. When these circumstances are deranged, elasticity comes into play, and produces a shrinking of the substance. In other words, every part is kept upon the stretch, and retracts when set at liberty by the removal of the extending cause. This will happen when its extremities are brought nearer to one another, when the contents of the hollow parts are withdrawn, and whenever they are divided transversely. This property has long been known, though described under different names; that of *tone*, or *tonicity*, has frequently been applied to it. Bichat, who has very well described its effects, has denominated it *contractilité de tissu*, and *contractilité par défaut d'extension*, and has distinguished it from tonicity, which he regards as a vital property.

Fibrous Tissues.

The mechanical properties we have enumerated are greatly modified by diversities of structure. The same substance, when in the state of greatest condensation, composes what Bichat has denominated the fibrous tissue. Chaussier has considered it as of a peculiar nature, differing from ordinary membrane, and has given it the name of *fibre albuginée*, ascribing to it the character of having a white colour, and a resplendent satin-like surface, an appearance which it owes to its great density. Of these fibres are the tendons, aponeuroses, and ligaments principally composed. Among these we may again trace a diversity of properties. Thus tendons exhibit the smallest degree of extensibility compatible with membranous texture, although they possess great flexibility. The ligaments belonging to joints are still more flexible, and somewhat more extensible and elastic. Those ligamentous structures, on the other hand, which are employed as an antagonist power to gravitation, or to muscular action, such as the ligamentum nuchæ, which counteracts the weight of the head in grazing quadrupeds, are very extensible, and possess a high degree of elasticity. A layer of the same elastic substance extends over the parietes of the abdomen in these animals, for the support of the abdominal viscera. The elastic ligaments which retract the claws of the cat, and other animals of the same tribe, exhibit the same property. Béclard considers this highly elastic substance as a separate modification of membranous structure, distinguished from the *tissu albuginé* of Chaussier by its yellow colour and peculiar elasticity. Ligaments, having the same properties, but which are white, instead of yellow, are extensively met with in the anatomy of insects.

Physiology.

Property of Corrugation.

Among the physical properties of animal membrane must also be enumerated a peculiar kind of contractility, which is accompanied with a sudden corrugation and curling of its substance. This effect, which was noticed by Haller, and which Bichat designates by the term *racornissement*, is produced by the application of a certain degree of heat, and also of several chemical agents, more especially the concentrated mineral acids. Alcohol and the neutral salts effect a similar change, but much more slowly, and in a very inferior degree; and the effect continues to increase if the agent continues applied, which is not the case when acids or boiling water are used. The continued applications of these latter agents gradually effect the disorganization and solution of the animal matter. Bichat has taken considerable pains to investigate these phenomena, and we must refer our readers to his *Anatomie Générale* for the details of his experiments. He has pointed out several circumstances by which this property is distinguished from mere membranous elasticity. Although it has been thought to resemble muscular contractility, it will really be found, when strictly compared, to differ from this last property in all essential particulars; and it probably, therefore, depends on causes that are wholly different.

Hygrometric Property.

An effect somewhat analogous to the former, although much less in degree, takes place in animal membranes by the evaporation of the water which is united to it, but which appears to be retained by a weak affinity. This constitutes what may be called the *hygrometric property*, and is very characteristic of dry membranous structures, all of which are found more or less to contract by the loss of moisture, and again to expand by its reabsorption, according to the varying states of dryness and humidity in the surrounding atmosphere. The organic tissues of vegetables exhibit this property; but in a very inferior degree compared with animal membrane.

Vis Mortua of Haller.

The mechanical properties of membrane which we have been examining are totally independent of the vital properties that are next to come under our review. They remain some time after the complete extinction of life in all its functions, and seem to be connected with the peculiar arrangement of particles, and the chemical composition of the substance in which they reside. They appear, indeed, not to be affected until the progress of decomposition has become sensible. Hence this assemblage of powers was denominated by Haller the *vis mortua*.

Contractility of the Muscular Fibre.

II. Muscular contractility is one of the most remarkable of those properties which are peculiar to animal life. It is often distinguished by the name of *irritability*, which was originally given to it by Glisson. But the merit of having clearly appreciated its importance, as a separate and peculiar power, is due to Haller, who speaks of it sometimes under the title of irritability, and sometimes under that of the *vis insita*. The phenomena of muscular contraction have already been sufficiently detailed in the Article Physiology in the *Encyclopædia*.

This property has been established in the system as the great source of mechanical power required for the operations of the animal machine. As in a manufactory where the force of steam is employed as the prime mover of the whole of its complicated machinery, so, in the animal system, is the muscular power resorted to on every occasion where mechanical force is required. From its vast intensity, this power appears adequate to every purpose; and though, in some instances, it may seem to have been lavished with profuseness for the sake of slight additional convenience, in others it is carefully economized; and perhaps more accurate examination would show that it is in all cases exactly adjusted to the intended effect. Before the time of Haller it was generally regarded as an extension of the nervous power; and so great was the confusion of ideas on this subject, that even Boerhaave speaks of tendon as merely a modification of muscular structure.

The occasion, or exciting cause, which gives rise to the exertion of this power, is termed a stimulus. Thus all muscular contraction implies two things, the irritability, which constitutes the power, and the stimulus, which determines the action of that power. The irritability, according to Haller, is the same in kind, wherever muscular fibres are met with; it only varies in intensity in the different muscles: but it does not in all of them obey the same stimuli. The nervous power is the natural stimulus of all those muscles which are under the influence of the will: on the other hand, the muscles of involuntary motion are affected by stimuli of different kinds, which are appropriated to their different functions, and altogether different from the nervous power. Thus the blood is the natural stimulus which excites the contraction of the heart; and the alimentary canal, the bladder, uterus, &c. are, in like manner, excited to action by their respective contents.

Its Organization.

It is only by examining attentively the circumstances in which the muscular power is exerted, that we can hope to attain a knowledge of its nature. That a particular mechanical structure is required for its production is apparent from the regular arrangement of parallel fibres, connected into fasciculi of larger and larger dimensions by separate investments of membrane; and also from their great vascularity. Muscles are more abundantly supplied with blood-vessels than any other parts, excepting the lungs and the organs appropriated for secretion. The minute or capillary veins are more particularly numerous, forming a vascular net-work, and are provided with numerous valves. Much contrariety of evidence exists as to the intimate structure of muscular fibres. Leeuwenhoek represents them as being exceedingly minute, many thousand uniting to form one visible fibre, but that they differ considerably in diameter in different animals, without any relation to the size of the animal. He states, for example, the fibre of the frog to be larger than that of the ox. He thinks their size also varies according to the age of the animal, being smallest in the earlier periods of life. Muys, who was engaged for many years in the most laborious researches on this subject, concludes, on the other hand, that the real ultimate filaments of muscles are in all cases of the same size, even when compared among the mammalia, birds, and insects. Prochaska, again, says expressly that they are not all of the

same diameter, but differ in different animals, and even in different parts of the same animal. Their diameter has in general been stated as less than that of the globules of the blood; but Sprengel speaks of them as being equal to the 500th of an inch in the mammalia, and the 250th in birds and fishes. Some microscopical observers have represented them as hollow tubes; but this is probably an optical deception, like that which has led to the belief that hairs are tubular. Several, such as King and Tauvry, have imagined them to be continuations of arteries; an opinion which was connected with the theory of the indefinite extension of vascularity, formerly prevalent, but since sufficiently refuted by observation as well as reasoning. Prochaska asserts, with confidence, that they are solid, and of a polyhedral, prismatic shape, generally flattened, or thicker on one side than on another, so that a transverse section presented an appearance similar to that of basaltic pillars. Hook and Swammerdam reported the fibres to be composed of a series of globules. Cooper and Stuart supposed them to be cellular, and Borelli that they were formed of a string of rhomboidal vesicles. Fontana's account of them in general agrees with that of Prochaska; but he remarks that they are furnished, at regular intervals, with transverse bands; and that they may always be distinguished by their parallel disposition from the fibres of membrane, which are more or less contorted. Sir Anthony Carlisle states, that a muscular fibre, duly prepared, by washing away the adhering extraneous substances, and exposed to view in a powerful microscope, appears to be a solid cylinder, the covering of which is reticular membrane, and the contained part a dry pulpy substance, irregularly granulated, and of little cohesive power, when dead. Mr Bauer represents them as composed of a row of globules, exactly corresponding in size to those of the blood, when deprived of their colouring matter. By long maceration in water, the cohesion of these globules is loosened, and the fibre is broken down into a mass of globules. The statement of these various opinions is sufficient to show how little satisfactory information has been gained on the subject. Whenever an observer has a favourite theory to support, the microscope is ever ready to assist him in seeing what he expects, or wishes to discover.

Mechanical Theories of Muscular Motion.

In the infancy of rational physiology, much labour was bestowed upon devising some mechanical arrangement of particles that might account for the phenomena of muscular contraction. With this view Borelli contrived his rhomboidal vesicles, which he supposed to be empty in the relaxed state of the fibre, but suddenly distended by the introduction of a fluid derived from the nerves, which shortened as well as swelled each vesicle, and, consequently, the whole muscle. In this hypothesis, though ingeniously adapted to the phenomena, no power is assigned for the sudden propulsion of so large a quantity of fluid into the vesicles; the resistance that would be opposed to the entry of such a fluid would be immense, and the force required to overcome it would be much greater than even that exerted by the muscle itself, which it was the object of the hypothesis to explain. The supposition, therefore, involves a greater difficulty than the simple fact. Some have, in like manner, imagined they could explain the phenomena by the turgescence of the numerous arteries which are seen to cross the fibres at right angles; not recollecting that the very force which distends the arteries is itself derived from the muscular power of the heart and arterial trunks, which could not create a power greater than itself. The hypothesis of the spiral course of the ultimate fibres, a form which admitted of elongation or contraction, according to the degree of convolution, is as gratuitous as the preceding; and equally open to the objection that the original source of motion is left unexplained. Dr Fordyce states a fact which places it in a striking point of view, the circumstance of a new force being generated during muscular contraction. If the interior surface of the ventricle of the heart, detached from the body, be pricked gently by a needle introduced into its cavity, the ventricle will thereby be made to contract with such power as to force the needle deep into it. The force of the contraction of the ventricle must have been incomparably greater than the power with which it was pricked by the needle. Muscular power, indeed, bears not the least analogy to any of the other great principles in nature, which are original sources of mechanical force; and, until such an analogy can be traced, all our endeavours to explain the phenomena by mechanical hypothesis must be as fruitless as the attempts to contrive a machine for perpetual motion. Some physiologists, wishing to avoid all hypothesis, propose to explain the phenomena of muscular contraction, by saying that it arises from an increase of attraction among the particles of the muscular fibre. Dr Fordyce calls this force "the attraction of life," a term, which, if it has any meaning, is merely a statement of the simple fact under a new form of expression.

Chemical Theories.

Muscular fibres differ from those of membrane in chemical composition, as well as mechanical structure; and it becomes a question how far their properties depend on a peculiar combination of chemical elements. Physiologists have, accordingly, endeavoured to ascertain whether, while the mechanical texture was unaltered, any changes occurring in the chemical condition of a muscle would be accompanied by a corresponding change in its contractile power; and, whether there was any one element in particular, the presence of which was more essential than the rest to the exertion of that power. It was long the fashion to regard oxygen as the source of this power. This theory was advanced by Girtanner, and found strenuous advocates in Humboldt, Beddoes, and Richerand. Some account of the reasonings on which they founded this opinion has been given in the *Encyclopædia*. Experiments were made to ascertain the influence which the alternate abstraction and restoration of oxygen had on irritability, of the presence of which the galvanic excitation was used as a test. The general result of the inquiry was, that a certain proportion of uncombined oxygen is essential to the maintenance of irritability. The presence of fibrin has been regarded essential to the constitution of the muscular fibre; but Fourcroy has shown that different modifications of fibrin are compatible with irri-

tability. The necessity of a due supply of caloric has, in like manner, been the subject of inquiry; and, as might have been expected, the preservation of a certain temperature has been found requisite to muscular action. All that can be safely concluded, however, from these investigations, is, that a certain state of chemical composition and of temperature, is as essential as a certain mechanical structure to muscular contractility, but that these conditions admit of some degree of variation within certain limits.

In the more perfect animals, muscular contractility remains but for a short time after the circulation of the blood has ceased. A ligature on the arteries which distribute this fluid to a muscle, occasions the speedy loss of its irritability; arterial blood, therefore, supplies some material requisite for the preservation of the proper chemical state of the muscular fibre. Yet different classes of animals are very differently constituted with respect to this circumstance. The muscles of the amphibia will remain irritable long after an entire stop has been put to the circulation; and this takes place even in limbs that are detached from the body.

Cellular confounded with Muscular Contractility.

The operation of the muscular power is of so distinct and specific a character, that it appears surprising how phenomena of any other class could be confounded with it; and yet several distinguished physiologists have ascribed to different portions of the cellular substance a contractile power analogous to that of muscles. The *tunica vaginalis testis,* and its surrounding cellular tissue, are said to exhibit indications of this peculiar species of contractility, from the irritation of stimuli, or by the application of cold. "The contractions that ensue," says Bichat, "are doubtless not to be compared to that of muscles, but they certainly constitute the first degree of that power; they are the same in kind, or rather they hold a middle rank between muscular contractions and those minute and invisible oscillations which others call tonicity, &c." There does not appear to us to be any foundation in fact for this supposed gradation of the muscular power. The motions in question may partly be accounted for by the known power of elasticity, which undoubtedly varies in degree in different textures, and partly by the real but undetected presence of muscular fibres. The *vis cellulosa* of Blumenbach appears, in like manner, to be no new power, but simply the modified elasticity of the texture in which it resides. A few cases have been pointed out, which are perhaps of a dubious character, such as the motions of the iris, the muscularity of which has been often called in question, though it now appears to be sufficiently established by the microscopical observations of M. Bauer. So much importance has been attached to these apparent anomalies, that it has been thought necessary, in order to account for them, to suppose the existence of a new power, the *vita propria;* or rather, as it should be said, to invent a new term void of any definite signification.

Power of Spontaneous Elongation.

It has frequently been supposed, that, besides the power of contraction, muscular fibres had also the opposite power of spontaneous elongation, when the former ceased to be exerted. Bichat countenances this doctrine when he says, that "it appears very probable that the dilatation of muscles is a phenomenon equally vital with their contraction." But all the facts that have been adduced in favour of this notion may, as John Hunter has shown, be completely explained by the operation of other causes; such as that of antagonist muscles, or of the natural elasticity of neighbouring parts, or of the cellular substance contained in the muscle itself; for it should not be forgotten that a muscle, in addition to its contractility, possesses all the properties belonging to animal membrane, which composes so large a portion of its structure. Many phenomena in the movements of animals, which may, at first sight, have the appearance of arising from a spontaneous power of dilatation, such as the elongation of the trunk of the elephant, of the tentacula of polypi, and the bodies of the leech and other vermes, and the extension of the feet, and other soft parts of mollusca, are, like the varied motions of the tongue, only secondary effects of the contraction of certain muscular fibres so disposed as to produce these effects. It has been said that the heart has been found to exert, during its dilatation, a positive force, but probably if the course of all the fibres composing the muscular parietes of that organ were better known, this apparent anomaly would be as easily explained as the rest.

Still less could it have been supposed possible to confound the nervous with the muscular power; and yet, prior to the time of Haller, no clear ideas were entertained of the distinction between them; and, even in later times, the subject has been involved in much perplexity. Muscular fibres used to be spoken of as only nervous fibres on a large scale; exhibiting distinctly, on account of their greater magnitude, the contractions which were presumed to take place in the ultimate fibres of the nerves during their action, but which were insensible on account of their minuteness. The retraction of divided nerves is clearly an effect of membranous elasticity.

Phenomena of Nervous Agency.

III.—Nervous agency, or that property of the nervous system by which it receives impressions made on one part, and transmits them to others, is manifested in several ways. First, by exciting muscular contractions. The usual mode in which this occurs is seen in the muscles of voluntary motion, the actions of which are determined by an effort of the will, which produces an impression on the nerves sent to these muscles at their origin in the sensorium; this impression is propagated along these nerves to the muscles themselves, where it appears to act upon their irritability like any other stimulus, and to produce their contraction. But the very same effect takes place quite independently of the mind, by an irritation of a mechanical or chemical nature applied at the origin of the nerves, or in any part of their course. This conducting power in the nerves may, by these means, be called into action long after the extinction of sensibility, and may be observed even in a limb removed from the body; for muscular contractions are produced in it by mechanical irritation of the ends of the nerves leading to those muscles, and still more readily by galvanic excitation. The contraction of muscles which are not under the dominion of the

will, such as the heart, are not so evidently the consequence of irritations applied to the nerves which terminate in them, in consequence of the peculiar mode of arrangement of these nerves; but as we shall hereafter show, the conducting power of these nerves is no less real than in the former. Various stimuli, operating through the medium of the nervous system, and different affections of the mind, affect the motions of the heart and arterial system, and the muscular fibres of the alimentary canal; and produce local determinations of blood, and increased vascular actions of particular parts. Secondly, there are various operations, such as secretion, conducted in the minuter textures of the body by means that entirely escape our cognizance, which are materially influenced by certain irritations propagated along the nerves. But the mode in which this influence is exerted is reserved for future discussion. Thirdly, another, and no less important effect of nervous action is the production of sensation. An impression made upon the sentient extremity of a nerve is propagated to the sensorium, when it produces other changes, immediately followed by that affection of the sentient principle, accompanied by consciousness, which we term sensation. This latter class of effects we shall refer, as already stated, to a power distinct from the nervous, and which we have called the sensorial power. Fourthly, among the effects resulting from the nervous power, those which arise from the communication of irritations to very remote parts, which are but indirectly connected by nerves, must not be omitted. They are usually comprehended under the title of the effects of sympathy. In some cases the nervous communications may be traced; in others, it appears to take place through the medium of the central parts of the nervous system, that is, the brain and spinal marrow. In proportion as the anatomy of the nervous system has been more accurately explored, the former appear to be more numerous; though there are still a great number of cases which can only be explained on the latter supposition.

Analogies with Electricity.

In what way this propagation of impressions by the nerves is effected, we are wholly ignorant. The celerity with which they are transmitted along the whole line of communication, bears a greater resemblance to the transmission of the electric agency along conducting wires, than to any other fact we are acquainted with in nature: and on the strength of this analogy the nervous influence itself has often been conceived to be of an electrical nature. In those fishes which exhibit powerful electrical phenomena, as the torpedo, gymnotus, and silurus, the organs appropriated to the production of these effects, are supplied with an enormous mass of nerves, showing clearly the important part which the nervous influence plays in these phenomena. The processes of secretion are disturbed when the nervous communications between the secreting organ and the brain are intercepted by the division of the nerves; but in the case of the stomach, the natural process of digestion is resumed when galvanic electricity is transmitted through those portions of the nerves which remain connected with the stomach. As Voltaic electricity is known to produce chemical changes in the substances on which it is made to act, it was conceived that the chemical changes constituting secretion were in like manner effected by electricity, of which the nerves were the conductors. Such are the principal arguments brought forward in support of the identity of the nervous and the electrical agencies; a hypothesis which was first advanced by Valli at the period when the effects of Galvanism on the muscles, or animal electricity, as it was then called, began to engage the attention of the philosophic world. We shall have occasion to revert to this theory in the sequel.

Organization of Nervous Matter.

The nervous, like the other animal powers, is dependant on a certain mechanical and chemical constitution of the organs which exercise it. Anatomists are not agreed as to the minute and ultimate structure of nervous matter. Ruysch and Leeuwenhoek considered it as vascular, an opinion to which Haller subscribes; but Albinus denies the vascularity of the medullary substance, as neither apparent by the microscope, nor by the evidence of injections. De la Torre asserts that it consists of a mass of innumerable transparent globules swimming in a diaphanous fluid; and that these globules are larger in the brain than in the spinal marrow. Prochaska describes the same globular structure, which he represents as united by a transparent elastic cellular membrane, disposed in fibres. Monro first thought these fibres to be convoluted, but afterwards suspected some optical deception. Fontana found the nerves to be composed of a number of minute cylinders, seemingly composed of a pellicle, and partly filled with a transparent gelatinous humour, and with small unequal globules. Sir Everard Home describes the optic nerves of a horse as "composed of two parts, one opaque, and the other transparent, forming fibres of a peculiar kind, unlike those of any other part of the body. Their course is curious, for they appear to be constantly passing from one fasciculus to another, so as to connect all the different fasciculi together by a mixture of fibres. This is different from the course of the blood-vessels, lymphatics, or muscular fibres; the only thing similar to it is in the formation of nervous plexuses, which leads to the idea of its answering an essential purpose respecting the functions of the nerves."

Conditions requisite for the Phenomena.

Whatever be the peculiar organization from which such astonishing effects result, we may at least be assured that the following conditions are requisite for their appearance; namely, a certain continuity of nervous substance, freedom from pressure, and the continued supply of arterial blood. With respect to the first of these conditions, however, the experiments of Dr Philip and of Mr Brodie, the results of which are stated in the *Philosophical Transactions* for 1822, would seem to show that the mere division of a nerve, if the cut ends are not above a quarter of an inch asunder, is not sufficient to interrupt the transmission of that portion of nervous influence with which the secretions are concerned. It is to be hoped that the prosecution of this curious and important discovery will throw some light on the mysterious nature of nervous agency.

Sources of Nervous Power.

As the nerves, in warm-blooded animals, lose their power in a very short time after they are isolated from the rest of the system, it has been naturally

conceived that they derive a supply of power from the large central masses constituting the brain and spinal marrow, where it may be supposed to be prepared and elaborated, in a manner somewhat analogous to the process of secretion. It has been further imagined, that this power was capable of being accumulated in the brain and spinal marrow, forming a kind of stock or perpetual source, to supply the expenditure that takes place by the several nerves, which conduct it off. Prochaska, on the other hand, thinks that the nervous power is generated throughout the whole extent of the nervous system, so that every part derives from its own nerves, taken alone, the cause of its life and movements. There are facts in favour of each side of the question, and the subject is still involved in considerable obscurity.

Phenomena of Sensorial Power.

IV.—Sensorial Power is manifested in the production of sensation and volition. These effects, when they occur in ourselves, we know by consciousness, but in other animals we can only infer their presence by the voluntary actions to which they give rise; that is, by the well-marked expressions of pain or pleasure, and by the contraction of certain muscles, with the evident intentions of gratifying natural appetites, or of avoiding or removing what occasions pain. The term *sensibility* has been used by modern writers with great latitude, as expressing generally the capacity of being affected by impressions. Thus Bichat speaks of organic sensibility as contradistinguished from animal sensibility. But the extension of this term to any property that does not involve sensation attended with consciousness, is too indefinite, and tends to introduce a confusion of ideas. The nervous and sensorial powers, though in themselves perfectly distinct, had, in general, been confounded together by physiologists. Le Gallois was the first who pointed out the difference between them; but their distinctive characters have been most clearly marked by Dr Philip in his *Experimental Inquiry into the Laws of the Vital Functions*, a work which has opened new and important views in this department of physiological science. He has brought evidence to show that these two systems do not differ less from each other than they do from the muscular system. It appears from his observations, that after the destruction of the sensorial power, the nervous power is still capable of performing its other functions, although it can no longer excite sensation, because the power on which sensation depends no longer exists. This happens, as we shall afterwards have occasion to notice, at the instant of death.

Powers of Exciting Sensation.

The power of sensation is called into action by impressions conveyed along the nerves: and the nerves appear to be the only medium through which these impressions can reach those parts of the nervous system, on the changes of which sensation depends. It has, however, been asserted, that other parts, besides the nerves, are endowed with this power. It is alleged, for instance, that muscular fibres are sensible, because the sensation accompanying muscular contraction is different from that of passive impressions; and because spasms are attended with peculiar pain. But experience shows, that the power of exciting sensation is very variable in the nerves of the same part, according to the affections of that part. Increased determination of blood to any organ generally augments its sensibility. Inflammation exalts it in a still more remarkable degree, so that parts usually insensible, as the bones, tendons, and ligaments, become exquisitely sensible in many states of disease. The marrow of cylindrical bones appears, under ordinary circumstances, to possess very little sensibility, as is seen in amputations: but in other states, it becomes highly sensible; and, if irritation be applied in particular ways, as by pressure over a certain extent of marrow, the most acute pain is immediately felt. These variations will explain the difference and even contrariety of statements that have been made by different physiologists on this subject. The greater number of experimentalists have denied that it possessed any sensibility. Duverney and Bichat, on the other hand, represent it as highly sensible. Béclard remarks, that we cannot draw any correct inference from what happens in amputation, because the intense pain suffered during the section of the soft parts, has rendered the animal scarcely sensible to a lesser degree of pain immediately succeeding: but that, if the operation be suspended until this first impression has in a great measure subsided, any injury done to the marrow will be acutely perceived. It appears, indeed, that different nerves have very different powers of exciting sensation: but the consideration of this subject involves the discussion of a previous question of great interest, and on which some light has been thrown by recent discoveries.

Differences in the Functions of different Nerves.

The nervous power is manifested, as we have already stated, by the transmission of impressions. Some of these impressions, arising from the remote extremities of the nerves, are conveyed to the sensorium, and produce sensation: others originate in the sensorium, being consequent on acts of volition, and are transmitted to the muscles. With regard to these processes, which take place in opposite directions, the following questions may be asked:—Are the impressions, as far as regards the nerves, in both cases of the same kind, and modified only by the structure of the organs of sense, of that part of the sensorium with which the nerves communicate, and of the particular muscles in which they terminate: or, are the impressions modified by differences in the structure of the nerves, which are the vehicles of their transmission? Or, in other words, are all nervous filaments alike in function, merely conveying, like electric conductors, the same agent exactly as they receive it? In particular, can the same nerve, or nervous filament, transmit both kinds of impressions, namely, those of sensation and of volition: and, if they can, do these impressions, which pass in opposite directions, ever clash and interfere with one another; or do they cross one another, without collision, like the rays of light through a lens? Or, are there two sets of fibres, the one for sensation, and the other for motion, as there are veins and arteries for the transmission of blood in opposite directions? The observations which seem first to have suggested this latter notion, were taken

from cases of partial paralysis of a limb, in which the power of motion remains, although that of sensation is lost. Some experiments of Arnemann's, in which nerves that had been divided, and had spontaneously reunited, were found to have recovered the power of the voluntary excitement of the muscles, but to have permanently lost the power of producing sensation, showed the possibility of a separation of these two functions.

The doctrine of there being two sets of nerves appropriated to these respective offices, had been taught, in the infancy of the science, by Erasistratus and Herophilus; and Galen was inclined to adopt the same opinion, from observing that both in the tongue and in the eye, the nerves supplying these organs are of two kinds. Galen, however, accounted for the anomaly in cases of paralysis, by saying, that a greater nervous power is necessary for motion than for sensation; so that sufficient might remain for the latter, when it was inadequate to the former function. Haller and Sauvages have both subscribed to this doctrine, and the consequences deduced from it. Dr Philip thinks we must admit that the bundles of nerves going directly from the brain or spinal marrow to any part of the body, contain nerves of two descriptions, one set adapted to convey the dictates of the will, the other to convey impressions from the part to the sensorium. This, he thinks, more probable than that impressions move backwards and forwards in actually the same channels. One of these opinions must be correct. If the former is so, there is no difficulty in accounting for the feeling being lost and the power of motion remaining, and *vice versa*. Indeed, these phenomena of disease seem to go some way towards proving the former opinion. Mr Charles Bell, also, is of opinion that the nerves which we trace in the body are not single nerves, possessing various powers, but bundles of different nerves, the filaments of which are united for the convenience of distribution, but which are distinct in their office, as well as in their origin. "It is remarkable," he observes, "that an impression made on two different nerves of sense, though with the same instrument, will produce two distinct sensations; and the ideas resulting will only have relation to the organ affected. There are four kinds of papillæ on the tongue, but with two of those only we have to do at present. Of these, the papillæ of one kind form the seat of the sense of taste; the other papillæ, more numerous and smaller, resemble the extremities of the nerves in the common skin, and are the organs of touch in the tongue. When I take a sharp steel point, and touch one of these papillæ, I feel the sharpness. The sense of touch informs me of the shape of the instrument. When I touch a papilla of taste, I have no sensation similar to the former. I do not know that a point touches the tongue, but I am sensible of a metallic taste, and the sensation passes backward on the tongue." Richerand states some experiments which he made on dogs, from which it appears that the functions of the different nerves sent to the tongue are widely different. (*Elem. de Physiologie*, T. II. p. 66, 8th edition.)

That the functions of the different sets of filaments composing the spinal nerves, and which arise respectively from the anterior and from the posterior fasciculi of the spinal marrow, are exceedingly different, has been proved by an experiment of Mr Bell's, of which he gives the following account. Former researches had led him to suspect that the functions of these two portions of the spinal marrow were different. He found that injury done to the anterior portion convulsed the animal more certainly than injury done to the posterior portion: but it was difficult to make the experiment without injuring both portions. But on considering that the spinal nerves have a double root, and being of opinion that the properties of the nerves are derived from their connexions with the parts of the brain, he thought this an opportunity of putting that opinion to the test of experiment, and of proving at the same time that nerves of different endowments were in the same cord, and inclosed in the same sheath. On laying bare the roots of the spinal nerves, he found that he could cut across the posterior fasciculus of nerves, which took its origin from the posterior portion of the spinal marrow, without convulsing the muscles of the back; but that on touching the anterior fasciculus with the point of the knife, the muscles of the back were immediately convulsed.

Original and Superadded Systems of Nerves.

In a paper published in the *Philosophical Transactions* for 1821, Mr Bell considers the nerves as distinguished, from their functions, into two classes; the one composing what he calls the original or symmetrical system, and the other the superadded or irregular system. The former are more expressly provided for the purposes of sensation and locomotion. In animals where these functions are not complicated with those of circulation and respiration by central organs, these nerves are very simple, consisting merely of two cords, running the whole length of the body, and giving off lateral branches to the several divisions of which their annulated frame is composed. This is the case with insects, and with most of the vermes. As we ascend to the higher orders of animals, we find a greater complication of functions and a greater intricacy of nervous connexions, arising from the necessity of establishing extensive links of association between the organs that perform these additional functions. Hence the second class of nerves are provided, which crossing the former in a variety of directions, and occasionally uniting with them, gives rise to the intricacy and apparent confusion, in which the anatomy of the nervous system has hitherto been involved. The nerves belonging to the first class may be distinguished in the human body as forming the original system, if abstraction be made of all the superadded nerves. The nerves of the spine, the tenth or sub-occipital nerve, and the fifth or trigeminas of the system of Willis, constitute this system. All these nerves agree in the following essential circumstances: they have all double origins; they have all ganglia on one of their roots; they go out laterally to certain divisions of the body; they do not interfere to unite the divisions of the frame; they are all muscular nerves, ordering the voluntary motions of the frame; they are all exqusitely sensible, and the source of the common sensibility of the surfaces of the body. When accurately represented on paper, they are seen to pervade every part; no part is

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without them; and yet they are symmetrical and simple, as the nerves of the lower animals. On the other hand, the nerves which connect the internal organs of respiration with the sensibilities of remote parts, and with the respiratory muscles, are distinguished from the former by their not arising from double roots, and having no ganglia on their origins; they come off from the *medulla oblongata* and upper part of the spinal marrow; and from this origin, they diverge to those several remote parts of the frame, which are combined in the motions of respiration. If the nerves be exposed in a living animal, those of the former class exhibit the highest degree of sensibility; while, on the contrary, those of the second are comparatively so little sensible, as to be immediately distinguished: in so much that the quiescence of the animal suggests a doubt whether they be sensible in any degree whatever. If the fifth pair, and the *portio dura* of the seventh, be both exposed on the face of a living animal, there will not remain the slightest doubt in the mind of the experimenter, which of these nerves bestows sensibility. If the nerve of the first class be divided, the skin and cellular substance are deprived of sensibility; but the division of nerves not belonging to this class does not at all deprive the parts of their sensibility to external impression. There is also a wide distinction in their powers of exciting the muscles. The slightest touch on the *portio dura* convulses the muscles of the face, but the animal gives no sign of pain: while, by means of the branches of the fifth pair, which, if touched, give great pain, it is difficult to produce any degree of action in the muscles.

Immediate Seat of Sensation;

The brain has, from the earliest times, been regarded as the organ chiefly connected with the affections of the sentient and intelligent principle. Galen taught that the governing spirit resides in the brain, and is especially contained in the ventricles, where it acts upon the nerves at their origin: for, on opening them, he observes, the spirit escapes, and the animal is immediately deprived of sensation and motion. The immediate seat of sensation appears to be confined to a particular portion of the nervous system; and observation and experiment concur in showing that this portion is restricted to much narrower limits than was formerly imagined. It certainly does not extend to the great mass of the hemispheres of the brain: for these may be wounded, or even wholly removed, in a living animal, without any indication of suffering. Both Le Gallois and Dr Philip removed by successive slices the whole of the upper and anterior parts of the brain, without affecting the muscles of voluntary motion, or apparently giving any pain. The knife excited these actions only when it approached the origin of the nerves, and the spinal marrow. The part which performs the office of the sensorium, that is, whose changes are the intermediate links between the percipient soul and the material body, appears to differ in different animals. In man, and the tribes of mammalia most allied to him in structure, it is chiefly situated in the *medulla oblongata* and upper portion of the spinal marrow, at the origin of the principal nerves of the organs of sense, and of their muscles. In proportion as we descend to the inferior orders, it seems to be more diffused over the upper portions of the spinal marrow; but in no case does it belong to any precise point, being always diffused over a certain extent of medullary matter.

and of Volition.

It is also generally believed, and Le Gallois professes to be of this opinion, that the power of determining resides exclusively in the brain. If a salamander, says he, be decapitated at the first vertebra, it continues to live several days; but although the muscles of the trunk and limbs be moved with a force sufficient for all the purposes of progressive motion, the animal remains on the same spot, and may be left on a plate, with a little water, without risk of its escaping. On examining its movements we may perceive that they are without order, and without any apparent object. The feet move, each in different ways, without concert; so that, if any advance happen to be made in one direction, it is presently defeated by a movement in the opposite quarter. The same remark applies to decapitated frogs; they are no longer capable of leaping; or if any leaps are made, it is only by a sort of accident, when their hind legs act against any fixed obstacle. When placed on their back, they occasionally agitate their limbs, as if from a desire to change their situation, but they remain as they were placed, from their incapacity to combine the movements necessary for that purpose. But all animals under these circumstances move but little, unless they are touched; and this is readily conceivable, since of all the senses the touch is the only one that remains to transmit impressions. Decapitation is not necessary for the exhibition of these phenomena; division of the spinal marrow will present them, and afford the singular spectacle of the two portions of the same body animated by different principles of action, each having a sensorial existence independent of the other.

Not confined to the Brain.

Yet many actions of the living trunk of an animal appear to be governed by a sort of instinct, or obscure volition. Guinea-pigs and kittens, after they have recovered from the stupor produced by decapitation, seem strongly to feel pain from the wound in the neck, as appears by the alternate motions of their hind-feet towards that part. Sir Gilbert Blane reports that he divided the spinal marrow in a kitten a few days old, by cutting it across at the neck. The hind-paws being then irritated by pricking them, and by touching them with a hot wire, the muscles belonging to them were thrown into contraction, so as to produce the effect of shrinking from the injury. The same effects were observed in another kitten, after the head was entirely separated from the body. In repeating this experiment he found that when the spinal marrow was cut through between the lumbar vertebræ and the os sacrum, the posterior extremities no longer contracted, but the tail retained its sensibility. It is very certain that birds continue not only to live, but to walk and run, for some time after decapitation. The feats of the Emperor Commodus, who amused himself with striking off the heads of ostriches while they were running across the circus, by shooting at them arrows having a cutting edge, are well known: these animals, though headless, continued to run as before, and reached the end of the area before they dropped. Many physiologists

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Unity of the Sensorium incapable of Proof.

Although the unity of the power of perception of which we are conscious, naturally suggests the idea of some central organ in which the corresponding corporal impressions may be united, it is yet obvious that the necessity of such a union of parts does not admit of proof; and that it may be very possible to conceive the different parts of the sensorium disseminated among the organs at considerable distances from each other, and still to be capable of performing their functions, provided they were in sufficient correspondence with each other by nervous connexions.

Requisite Conditions in the Sensorium.

The physiological conditions of the sensorium necessary for the exercise of the sensorial powers, besides the proper organization, chemical composition, and temperature, are freedom from compression, and a due supply by circulation of blood having the arterial qualities. Galen had proved by experiment that the ligature of both carotids in animals produced but little inconvenience; the circulation being in that case kept up by the vertebral arteries. Richerand succeeded in placing a ligature around these arteries, after the carotids had been tied, in a dog. Death in a few seconds was the consequence of this total interruption of circulation in the brain. In fainting, the loss of sensibility proceeds, in like manner, from the deficiency of blood in the brain. The insensibility which supervenes on the interruption to respiration is owing to another cause, namely, the presence of venous or carbonized blood in the arteries of the brain, in consequence of the circulating fluid being prevented from undergoing the usual salutary changes in the lungs. A similar loss of power in the spinal marrow is the consequence of depriving it of its circulating blood. This is proved by an experiment of Steno's, in which the tying of the aorta at the first lumbar vertebra was soon followed by paralysis of the posterior part of the body. Le Gallois, on repeating the experiment, found that if, after this effect had been completely produced, the ligature be removed, the powers of sensation and motion were gradually recovered, in proportion as the circulation was restored. He found also that the nervous and sensorial powers may be preserved even in a small portion of the trunk isolated from the rest of the system, by keeping up the circulation in that part, for which purpose, the maintenance of artificial respiration, and previous decollation, are indispensable. He seems to think that each portion of the spinal marrow might thus be made a separate centre of sensation and of life. In dogs, Sir Astley Cooper found that a ligature upon the aorta produced only slight weakness in the hinder extremities.

The necessity of a renewal of blood differs considerably in degree in different classes of animals. The amphibia are well known to be remarkably tenacious of life, in all its leading features. Both the nervous and the sensorial powers remain entire, in these animals, for a considerable time after the heart has been taken out, and the vessels drained of their blood. It has been found, indeed, by Dr Philip, that an obscure kind of circulation is kept up in the capillary vessels, after their communication with the heart is intercepted; but it appears probable that even this imperfect circulation, or rather oscillation of fluids in the vessels, must be exhausted in a much shorter period than that during which we see the nervous functions still survive. Greater tenacity of life exists in the nervous systems of animals in proportion as they are young: and it appears to be greater in the smaller than in the larger mammalia. The head of a rabbit, when severed from the trunk, shows signs of sensibility by the motion of the eyes and jaws, which latter are repeatedly opened and closed, as if vainly gasping for breath. Le Gallois observed, in rabbits decapitated on the day of their birth, that these movements continued for about twenty minutes. If the operation be performed at the end of fifteen days, they do not last above three minutes: and in rabbits of a month old, they cease in one minute, or in a minute and a half. The period during which sensibility remains in the trunk is generally less than in the head: but in both it is considerably longer in young than in adult animals.

Secretion, the Effect of a peculiar Power;

V.—Secretion, and other organic changes taking place in the living body, imply a complex series of operations, which the present state of our knowledge affords us no adequate means of analyzing satisfactorily. It is conceivable that a simple mechanical process, analogous to filtration, might effect the separation of some of the simpler fluids, such as serum, from the blood; a purpose which would be answered by a finer set of vessels, admitting only the passage of the thinner portions of the blood. Such a process would, therefore, imply only the mechanical agents and forces concerned in the circulation, and the organization of some of the secreting organs appears well adapted to this simple object. The existence of minuter series of capillary vessels in these organs has been established by an experiment of Bleulaud's, who injected, through the mesenteric arteries, a mixture of two differently coloured fluids, and found that the thinner fluid had penetrated into a net-work of

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vessels of a different order from those admitting the thicker fluid; and their course could be traced as they arose from the minute arteries, and terminated in the veins. But this explanation can apply but to very few of the animal secretions; since by far the greater number exhibit changes of chemical composition quite independent of mechanical separation.

No anatomical examination of the minute structure of secreting organs can be expected to throw much light on the means employed in this process, because those means transcend mere mechanism. The series of vessels, which, ramifying into tubes of smaller and smaller diameter, must have the effect of subdividing the blood, as by a strainer, to a certain degree of tenuity, probably prepare it for the changes it is to undergo in that part of the process in which the real chemical change consists; but farther than this we cannot venture to speculate, since we, in most cases, know so little what are the exact changes produced, and still less what are the particular affinities which must be called into play in effecting these changes. Their operation probably takes place in the parts where the vessels terminate, and beyond the influence of the power which propels the blood; for they occur in insects, in the system of which, it is now well ascertained, no circulation of blood exists, nor can even any vessels be traced, except such as convey air.

as also Nutrition, Growth, &c.

The appropriation of the materials thus elaborated to the purposes of growth, and the reparation of the solid structures of the body, is another stage of the same mysterious process, to the solution of which no conceivable mechanical or chemical hypothesis is at all adequate. The analogy of crystallization, although referred to in the celebrated definitions of Linnæus, is far too vague and remote to engage our serious attention: the growth of an animal or a plant being a phenomenon of a totally different class from the accretion of a stone or the shooting of a crystal. The phenomena of secretion and nutrition, inexplicable as they are at present, are sufficiently allied to each other to justify our reference of them to the same general head, until the progress of discovery may enable us to establish correct distinctions between them. Bichat, who has classed them together, subdivides them into two orders, as effects of *organic sensibility* and of *insensible organic contractility*, implying a distinction for which there appears to be no clear foundation. The terms themselves are inappropriate: we have already objected to the extension of the term *sensibility* to changes of which sensation forms no part; and *contractility* is, for the same reason, improperly implied to any organic phenomena in which contractions are neither apparent nor necessarily implied. We have selected the term *organic affinities* as best adapted to express the powers which produce these organic changes. Whether the coagulability of certain animal fluids, such as the blood, ought to be ranked under this head, or be regarded as a new and specific power, might perhaps admit of discussion; but we have not room to enlarge upon this question.

and Animal Temperature.

Increase of temperature is a phenomenon commonly attendant on the exercise of the organic affinities; that is, it usually accompanies the chemical changes that are continually taking place in the living body. It is evidently, however, only a concomitant, not an essential circumstance; for in some cases the contrary takes place, and a reduction of temperature occurs. It has lately been the fashion to speak of caloric as being a secretion, and to regard its evolution as a phenomenon referable to the class of secreting processes. The chemical theories that formerly prevailed with regard to animal temperature have, no doubt, been in some measure shaken by the experiments of Mr Brodie and of Dr Philip; but they are, perhaps, not so completely overthrown as some would endeavour to persuade us.

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Mutual Connexions of the Vital Powers.

VI.—Having thus endeavoured to trace the distinctive characters of each of the classes of vital powers, we have further to inquire into their mutual connexions and relative dependencies on each other.

Phenomena of Evolution,

Physiologists have endeavoured in vain to discover whether any one of these powers might be considered as the source of the rest. The evolution of the embryo has been anxiously studied with a view to this question. The first powers that appear to be called forth in the original developement of parts are the organic affinities; but, long before the period to which any accurate observation can reach, the muscular and the nervous powers have both displayed their energies. Already has the *punctum saliens* vibrated to the excitements of the fluid which it urges forwards; and the spinal marrow and brain, yet in a semifluid state, have already exerted their influence on the nascent organization. Tiedemann has bestowed great pains in the investigation of the successive stages of evolution of the nervous system in the fœtus, and has surmounted many difficulties which had stopped the progress of former inquirers. The late researches of Mr Serres have also brought to light many new facts. An abstract of the labours of these anatomists is given by Béclard. The first part of the nervous system that appears to be formed, or at least that can be distinguished, is the spinal marrow, the upper extremity of which is slightly enlarged. The formation of the brain succeeds, but this organ remains long very little developed in comparison with the spinal marrow; in the more advanced periods of gestation it increases rapidly in size. The sensorial powers are evidently not developed till the others have been matured, and till the frame-work of the body has made considerable advances towards its perfect state.

and of Death.

The origin of the vital powers being thus veiled in impenetrable obscurity, the inquiry has been directed to the order of their extinction on the approach of death. But here, also, very little satisfactory information can be gleaned. We learn, however, that the sensorial powers, as they were the last to be developed, are invariably the first to disappear; for their continuance seems to require the most perfect co-operation of the sanguiferous and nervous powers. But the nervous power survives their destruction, and is still capable of performing all its functions, except that it can no longer give evidence of conveying impressions to the sensorium, since the functions of the sensorium are abolished.

No impression made on any part of the body is perceived, nor followed by any visible act of volition. The muscular power still remains, for if either the heart, or the muscles of voluntary motion be stimulated, they possess the power of contracting; a power which they lose only by slow degrees, a considerable time after the sensorial power has ceased to exist. It is also manifest that a certain portion of nervous power still remains; for if the nerves themselves, or those parts of the brain and spinal marrow from which they originate, be irritated, the corresponding muscles will be thrown into action—a proof that the nerves retain the power of conveying impressions. Haller made a variety of experiments to ascertain the comparative permanence of the irritability of different muscles; and a still more numerous series with the same view has been lately made by Nysten, in his *Recherches de Physiologie, et de Chimie Pathologique*. The order which he establishes is somewhat different from that of Haller; but it varies according to the mode of death, and the nature of the stimulus employed as a test. There is, however, no doubt that in the more perfect animals, the vital powers are so connected, that no one can exist long without the others. They are all, more or less, dependent for their continuance on the uniform supply of blood having the arterial qualities: a condition which involves the continuance of the circulation and of respiration; two functions, again, for the exercise of which the muscular power is essential. Thus an interruption to any one function soon reacts in a circle upon all the others, and involves in a common destruction all the vital energies; nothing remaining but those properties which the parts of the body possess in common with inert matter, and which are immediately dependent on their mechanical and chemical constitution.

Although, by this reciprocation of functions, the vital powers are intimately connected with one another, it is still very conceivable that they may all of them be essentially independent of each other: and this is perhaps the simplest hypothesis that the subject admits of. Setting out, then, with this supposition, it remains to be seen what modifications it must undergo. The sensorial power, it is evident, can never be manifested but through the medium of the nervous power; yet it may be conceived as existing separately and independently, although all proof of its separate existence is wanting. Muscular irritability, and the organic affinities are also considerably influenced by the nervous power; but it is not easy to determine the nature and extent of their connection. Prior to the time of Haller, the nervous system was considered as the general source of power in the body; and the contractile power of the muscles was regarded as derived altogether from this system, which was supposed to transmit this power to the muscular fibre in proportion as it was called for, and to regulate the quantity supplied. Haller, as we have seen, contended for the existence of a *vis insita*, or power essentially residing in the muscles themselves, independently of any condition of the nervous system, and only called into action by stimuli, of which, in the case of the voluntary muscles, the nervous influence is one, contributing, like all other stimuli, to exhaust it, instead of furnishing any fresh supply. Meckel adopted a sort of intermediate opinion, regarding the nervous influence as one of the conditions necessary for muscular contraction, just as the due circulation of blood is one of those conditions; and, at the same time, admitting the separate existence of a *vis insita*.

Independence of Muscular Contractility.

Upon the Hallerian doctrine of the independence of irritability, it is easy to explain the fact that a muscle detached from the body, such as the heart, will still contract when stimuli are applied. If all the nerves supplying the limbs of a frog be divided, and cut out close to the place where they enter the muscles, the latter still retain their contractility in as great a degree as when the nerves are entire. To this it has been replied, that the stimulus may still act through the medium of the portions of nerves that must always remain attached to the muscle, however carefully we may endeavour to dissect them away; and which nervous fibres may perhaps even constitute an essential part of the muscular fibre. This objection, though often urged, was never satisfactorily answered by Haller. Dr W. Philip has endeavoured to remove it by the following experiment, made with a view to ascertain whether a similar exhaustion of irritability would arise if the excitation of a muscle were produced through the medium of the nerves, or by other stimuli. "All the nerves supplying one of the hind legs of a frog were divided, so that it became completely paralytic. The skin was removed from the muscles of the leg, and salt sprinkled upon them, which being renewed from time to time, excited contractions in them for twelve minutes; at the end of this time they were found no longer capable of being excited. The corresponding muscles of the other limb, in which the nerves were entire, and of which consequently the animal had a perfect command, were then laid bare, and the salt applied to them in the same way. In ten minutes they ceased to contract, and the animal had lost the command of them. The nerves of this limb were now divided, as those of the other had been, but the excitability of the muscles, to which the salt had been applied, was gone. Its application excited no contraction in them. After the experiment, the muscles of the thighs in both limbs were found to contract forcibly on the application of salt. It excited equally strong contractions on both sides. In this experiment the excitability of the muscles whose nerves were entire was soonest exhausted. From this experiment it is evident that the nervous influence, far from bestowing excitability on the muscles, exhausts it like other stimuli. The excitability, therefore, is a property of the muscle itself." (*Experimental Inquiry*, 2d edit. p. 99.)

Difficulties attending the Hallerian Theory.

While the theory of Haller so easily explains the phenomena of the voluntary motions, many difficulties lie in the way of its application to the actions of the involuntary muscles, such as the heart, blood-vessels, stomach, intestines, gall-bladder, &c. These latter organs are usually excited to contract by stimuli of a mechanical or chemical nature applied directly to them, and generally by the mere distension resulting from the accumulation of their contents.

But if these were the only occasions which called them into action, what uses must be assigned to the cardiac nerves, which establish a connection between the heart and the nervous system; and how it is subject to the influence of the passions, except through the medium of the brain or sensorium, acting through the intervention of these nerves? On the other hand, it is asked, if the nervous power, derived from the brain, be essential to the motion of the heart, how is the circulation maintained in acephalous monsters; and how are we to account for the fact that the interruption of all communication between the brain and the heart does not stop the motion of the latter? The theory of Haller explains perfectly these latter circumstances, but does not accord with the former: the opposite view of the subject is consistent with the former, but is opposed by the latter set of phenomena.

Influence of the Nervous System on the Heart.

Various opinions have prevailed at different times as to the influence of the nervous system on the motions of the involuntary muscles, and especially of the heart; for an account of which we shall refer our readers to the report made to the class of Physical and Mathematical Sciences of the Institute of France, on the work of M. le Gallois, entitled, *Expériences sur le Principe de la Vie, notamment sur celui des Mouvemens du Cœur, et sur le Siége de ce Principe*, and of which a translation is given in Dr Philip's *Experimental Inquiry*. Le Gallois conceived that he had proved that the power of the heart is derived altogether from the spinal marrow, and not, as formerly supposed, from the brain. The following are the leading facts from which he draws this inference. He found that, by crushing the spinal marrow, the power of the heart is so enfeebled, that it can no longer propel the blood; but that, after the removal of the brain, the power of the heart still continues, and may even be preserved a considerable time by artificial inflation of the lungs, after the whole head has been separated from the body. He was thus at no loss to explain the use of the cardiac nerves; the heart being influenced by the spinal marrow through their intervention, and being also subject to the influence of the passions, because the spinal marrow is itself influenced by the brain. Dr Philip has shown that the above facts by no means warrant these inferences, and has established satisfactorily, by direct experiment, that the brain has just as much influence over the motions of the heart as the spinal marrow has, when the circumstances of the experiment are precisely the same. The removal of the spinal marrow, like that of the brain, if the experiment be performed with caution, and by slow degrees, does not sensibly affect the motion of the heart, the animal being previously deprived of its sensibility. In these experiments the circulation ceases quite as soon without as with the destruction of the spinal marrow. Loss of blood seems to be the chief cause of its cessation; and pain would also contribute to the same effect, if the animal were operated on without being rendered insensible. The results are the same in frogs, only they are more distinct, because less immediately affected by the loss of blood. In these animals, if the head and spinal marrow be removed, the heart continues to perform its functions perfectly for many hours, and seems not to be immediately affected by their removal. Mr Clift made a series of experiments to ascertain the influence of the spinal marrow on the action of the heart in fishes, and found that, whether the heart be exposed or not, its action continues long after the spinal marrow and brain are destroyed, and still longer when the brain is removed without injury to its substance.

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On the other hand, when the brain is suddenly crushed, as by a blow, which at once destroys its texture, the power of the heart is instantly so enfeebled, that it can no longer propel the blood. The same effect takes place if a similar injury be inflicted on the spinal marrow, as happened in Le Gallois' experiments. Dr Philip reports, that when the brain of a frog was crushed by the blow of a hammer, "the heart immediately performed a few quick and weak contractions. It then lay quite still for about half a minute. After this, its beating returned, but it supported the circulation very imperfectly. In ten minutes its vigour was so far restored that it again performed the circulation with freedom, but with less force than before the destruction of the brain. The spinal marrow was then crushed by one blow, as the brain had been. The heart again beat quickly and feebly for a few seconds, and then seemed wholly to have lost its power. In about a minute and a half it again began to beat, and in a few minutes acquired considerable power, and again supported the circulation. It beat more feebly, however, than before the spinal marrow was destroyed. It ceased to beat in about an hour and a half after the brain had been destroyed." In common cases of hemiplegia, the muscles carrying on the vital functions are seldom impaired: and Dr Cheyne of Dublin relates a case in which, while one half of the body was paralyzed, the uterus performed its function perfectly, by acting so as to expel a living fœtus.

It has generally been imagined that the action of the heart cannot be influenced by stimuli applied to the brain or spinal marrow; for it would seem an inconsistency to hold this opinion, and at the same time to admit that it is not influenced by the total removal of those organs. But Dr Philip found that the application of alcohol to the brain or to the spinal marrow of a rabbit, produced immediately a great increase in the action of the heart. An effect of the same kind, but in a much smaller degree, took place from the application of a watery solution of opium, and a still smaller effect from an infusion of tobacco. The increased action which had been excited was soon succeeded by a more languid action of the heart, than that which had existed before the application was made. Little or none of the debilitating effect was observed when alcohol was used, and the action of the heart, in this case, returned to its usual state. Effects in every respect similar were observed to take place, when the same experiments were repeated on frogs.

Effects of different Stimuli.

It appears, then, that there is no essential difference between the irritability of the muscles of voluntary and of involuntary motion, in as far as their independence on the nervous system is concerned;

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but yet they are influenced by different stimuli, or at least by stimuli applied in different ways. Hence the laws which regulate the effects of stimuli applied to the brain and spinal marrow on the heart and muscles of voluntary motion are different. Mechanical stimuli, such as cutting instruments, applied to the brain or spinal marrow, produce no effect on the muscles of voluntary motion, unless they are applied to those parts where the nerves originate; they then excite the most violent spasmodic actions. The heart, on the other hand, is but slightly accelerated in its motion by mechanical injury done to the brain or spinal marrow, in what part soever that injury be inflicted; but the heart is affected in proportion to the extent of the parts that are injured. It is most excited when the brain is wounded rapidly in many directions. Chemical stimuli, on the contrary, such as alcohol, applied to any part of the brain or spinal marrow, produce considerable and immediate increase of the motion of the heart; while the voluntary muscles are, at the same time, not at all affected, and the animal betrays no sense of pain. The general conclusion to be deduced from these facts is, that the heart is excited by all agents applied to any considerable part of the brain or spinal marrow, while the muscles of voluntary motion are excited only by more powerful agents applied to certain definite parts of these organs. Hence we may easily derive the explanation of the apparent anomalies formerly mentioned. The heart may continue its action when removed from the body, and when no brain or spinal marrow exists, because it has no direct dependence on any part of the nervous system. It is supplied with nerves, and subject to the influence of the passions; because, although independent of this system, it is capable of being influenced through it, especially by such causes as, like the passions, affect a considerable portion of the nervous system.

The same conclusions, derived from a series of analogous experiments, are found applicable to the powers of the vascular system employed in carrying on the circulation, and even to those of the minutest vessels which can be seen by a powerful microscope. The doctrine, indeed, may be extended generally to all the muscles of involuntary motion, or those parts possessing what Bichat would call *contractilité organique sensible.* The irritability of the stomach and intestines, from whence arises their peristaltic motion, is, like that of the heart and blood-vessels, independent of the nervous system, though capable of being influenced through it. It survives the destruction of the spinal marrow, and of the brain, or of both these organs. In rabbits the peristaltic motion continues till the parts become cold; so that, when the intestines exposed to the air have lost their power, that of those beneath still remains. The effects of the passions on the alimentary canal leave no room to doubt that its muscular fibres are capable of being stimulated by the direct influence of the nerves. But, from the extreme irregularity of their movements, we cannot so well ascertain whether they are subject to the influence of the different parts of the brain and spinal marrow, as in the case of the heart and blood-vessels.

Vital Powers concerned in Respiration.

Respiration is a function which requires for its perfect performance the combined agency of three great classes of vital powers, the sensorial, the nervous, and the muscular. It ceases immediately on the destruction of the sensorial power; a fact which is unexplained on the hypothesis of Le Gallois, that the nervous power alone is concerned. How it happens, that, after decapitation, the movements of inspiration are the only set of actions relating to this function that are annihilated, while the rest remain, is, according to that physiologist, "one of the greatest mysteries of the nervous power, the revealing of which would throw the strongest light upon the mechanism of the functions of this wonderful agency." The difficulty vanishes, according to Dr Philip, if we admit the sensorial power as acting a part in this process, and as being necessary to call into action the nervous and muscular powers. He considers the muscles of respiration as, in the strictest sense, muscles of voluntary motion. By a certain sensation originating in the lungs, a wish is excited to expand the chest. This is an act of the sensorium, and until it takes place, the nervous as well as the muscular power, by which its expansion is affected, remain inert. It is in vain that these powers survive, if the power which calls them into action be lost. Thus we can understand why the removal of the brain, or the injury to that part of the brain where the par vagum originates, or the division of the spinal marrow above the origin of the phrenic nerves, immediately puts a stop to respiration, and the animal perishes unless the lungs be artificially inflated.

System of Respiratory Nerves.

The number of muscles which have a relation to this function, and which may occasionally be called into play as auxiliaries, when, in consequence of some impediment to the natural motions, the muscles usually employed are inadequate to produce the full expansion of the chest, is extremely great. "When a post horse," says Mr Bell, "has run its stage, and the circulation is hurried, and the respiration excited, what is his condition? Does he breathe with his ribs only; with the muscles which raise and depress the chest? No. The flanks are in violent action; the neck as well as the chest is in powerful excitement; the nostrils as well as the throat keep time with the motion of the chest. It is quite obvious that some hundred muscles thus employed in the act of breathing, or in the common actions of coughing, sneezing, speaking, and singing, cannot be associated without cords of connection or affinity, which combine them in the performance of those actions: the nerves which serve this purpose I call the respiratory nerves." Some of the peculiarities in the structure of these nerves have already been noticed. The following are enumerated by Mr Bell as composing this system; the par vagum; the portio dura of the seventh pair, or respiratory nerve of the face; the spinal accessory nerve, or superior respiratory nerve of the trunk; the phrenic, or great internal respiratory nerve; the external respiratory nerve: and also, the glossopharyngeal nerve, or ninth of Willis, and the branches of the par vagum to the superior and inferior larynx. Mr Bell has deduced his theory from a great number of experiments made on animals. Thus, on dividing the portio dura on one side of the head, in an ass,

the motion of the nostril accompanying respiration immediately ceased on that side, while the other nostril continued to expand and contract in unison with the motions of the chest; and sneezing took place only on that side. But the voluntary motions of the lips, and other parts of the face, remained on both sides, and the animal could eat without impediment. The reverse took place on the division of the superior maxillary branch of the fifth pair; no change occurred in the motion of the nostril; the cartilages continued to expand regularly in time with the other parts which combine in the act of respiration, but the side of the lip was observed to hang low, and it was dragged to the other side. When the nerves on both sides were divided, the power of elevating and projecting the lips, necessary for gathering food, was lost. The effects of partial paralysis, which affects sometimes one set of nerves, and sometimes another, strikingly illustrate the truth of Mr Bell's theory, and have been accurately traced by Mr Shaw, in his papers in the *Journal of Science*, and more recently in a Memoir published in the twelfth volume of the *Medico-Chirurgical Transactions*.

Influence of Nervous Agency on the Organic Affinities.

It remains to be inquired, whether the organic affinities which give rise to the phenomena of secretion, nutrition, and animal temperature, are in immediate subordination, or are only occasionally under the influence of the nervous power. In as far as the materials on which the observed chemical changes are produced by the operation of these powers, are furnished to the secreting organs by the blood-vessels, secretion must evidently be influenced by all those causes which affect the circulation; many of which causes, we have seen, act through the medium of the nervous system. But with regard to that part of the process, which is conducted after the fluids have passed out of the capillary vessels, it is conceivable that they may still be carried on after the circulation has ceased, and may be influenced by totally different causes. The evidence of such processes being continued after the circulation is at an end, is obscure and defective. Stories have been told of certain secretions occurring after death; and of the hair and nails continuing to grow; but they have seldom been stated on authority to which any credit can be attached. Majendie, however, reports the fact of these parts growing for several days after death; and states, that he has seen a similar phenomenon with respect to the secretion of mucus. If the power which effects secretion, be independent of the other vital powers, these facts would admit of explanation; for it might survive the destruction of the vital powers for a certain period, in the same way that muscular contractility survives for a short time, the destruction of the sensorial and nervous powers. Hunter suspected that a vital action, referable to this class, continued in the stomach for some time after death, occasioning " an action and probably a secretion in the stomach." This he inferred from the well known fact that the coats of the stomach are often found digested, when examined after death. But Dr Philip remarks that this phenomenon is evidently the effect of a chemical, and not a vital process.

Dr Philip, who has so ably supported the doctrine of the independence of the muscular and nervous powers, has advanced an opinion directly the reverse of this with regard to the power of secretion, which he maintains is completely dependent on the nervous power. Such is the inference he deduces from a series of numerous experiments on the effects of dividing the par vagum on both sides of the neck in warm-blooded animals, and particularly in rabbits, in performing which, he was assisted by Dr Hastings. If this be done with proper precautions, the secretion of the gastric juice, and, consequently, the process of digestion is entirely suspended: great difficulty of breathing succeeds, and the air-cells of the lungs, with the bronchiæ, become clogged with a frothy mucus. Mr Brodie had already found that arsenic introduced into the system, after the division of these nerves, does not produce the copious secretion from the stomach and intestines, which it is found to do under ordinary circumstances; and he met with a similar result when he divided the stomachic nerves immediately above the cardiac orifice of the stomach. The destruction of any considerable portion of the spinal marrow also deranges the secreting power of the stomach. When the nervous influence is withdrawn, the capillaries continue to convey fluids to the secreting organs, because their action is independent of that influence: but the changes constituting secretion no longer take place; it is thence inferred, that the power of secretion is immediately dependent on the nervous power. Dr Alison, on the other hand, has contended, in some very ingenious essays published in the *Journal of Science*, that this is not a legitimate inference because, in the experiment of the division of the par vagum, other causes than the interruption of the influence of the brain, such as the immediate injury done to the nerves by the act of dividing them, might be assigned for the observed effects of this operation on secreting surfaces. Mr Shaw thinks, that the only inference that can be drawn from the phenomena of this experiment is, that, in consequence of the bond of connection between the stomach and the organs of respiration and circulation, being destroyed, the functions of the stomach will necessarily be more or less disturbed.

Dr Philip has been further led to conclude, that galvanism is identical with the nervous agency. This opinion is founded on the result of the experiments we have already alluded to, in which the galvanic influence, transmitted through the lower portions of the divided par vagum, restored the secretion of the gastric juice, and the digestion of the contents of the stomach, which would otherwise have ceased. The accuracy of the experiments was for a long time disputed, but has lately been satisfactorily established by their careful repetition at the Royal Institution, by Dr Philip, in conjunction with Mr Brodie. But though the fact be admitted, there appears reason to doubt whether it warrants the conclusion, which Dr Philip has boldly drawn from it, relative to the identity of the nervous and galvanic agencies. Dr Alison, in the papers above alluded to, has discussed this question with great acuteness. Our limits preclude us from entering into the arguments employed in the controversy. We shall only, therefore, add, that Dr Philip ascribes the

evolution of animal heat to the operation of the nervous power, and endeavours to show, by experiment, that the galvanic influence occasions an evolution of caloric from arterial blood, if subjected to it as soon as it leaves the vessels, but that it produces no such effect on venous blood; and also that the destruction of any considerable portion of the spinal marrow is followed by a reduction of the temperature of the animal.

Nervous Communications by Ganglions, &c.

In order that any one set of organs may be subjected to the influence of every part of another set, it is necessary that some very extensive mode of nervous communication should exist between them. Such appears to be the object of that complex system of ganglionic nerves, of which the branches of the great sympathetic compose so large a portion. All the organs which have muscles of involuntary motion, and which, as we have seen, are influenced by every part of the brain and spinal marrow, receive nerves from a chain of ganglions, to which filaments of nerves from all the parts of the brain and spinal marrow are sent. Thus the nerves issuing from those ganglions are made up of filaments from an infinite number of sources, and transmit to the organs in which they terminate the united influence of all the nerves which the ganglions have received from the brain and spinal marrow. Each ganglion may accordingly be regarded as a secondary centre of nervous influence, receiving supplies from all the parts of the brain and spinal marrow, and conveying to certain parts the united influence of these organs. On the other hand, as the muscles of voluntary motion are to be subjected to the influence of only small portions of these central parts of the nervous system, they receive their nerves directly from those parts; generally without the intervention of ganglia, and with comparatively few intermixtures of nervous filaments. The system of ganglionic nerves appears to be quite as extensive as that of nerves proceeding directly from the brain and spinal marrow. These views, developed by Dr Philip, are directly opposed to those of Bichat, who maintains that the ganglions are centres of nervous influence, independent of the brain and spinal marrow, and incapable of transmitting their influence; but they coincide with Bichat's opinion, that the great sympathetic derives its origin from the spine and not from the brain, with which it has only very slender communications.

General Conclusion.

We have thus attempted to delineate the characters of those powers by which the living animal body is distinguished from those of the inert materials that enter into its composition, and of which the combined effects constitute what is called *life;* and we have further endeavoured to investigate the laws of their mutual connections and dependencies. If the views we have presented are correct, they will enable us to detect the fallacy of those definitions of the vital principle, which have been from time to time advanced, in violation of the just rules of philosophical induction. The real state of the science does not yet authorize that degree of generalization which these definitions would imply. We are not warranted by the phenomena already known, in regarding life as the effect of any single power. The attempts of Brown, of Hunter, and of Bichat, to reduce the science to this state of simplification are premature, and have been the means of retarding, instead of promoting, the progress of real knowledge. The error has sometimes been that of generalizing partial views; so that one class of facts has been assumed as comprehending all the rest; but most frequently it has consisted in including a variety of dissimilar phenomena under the same common principle. We may take as an instance of the former, the definition of Le Gallois, which takes cognizance only of the nervous power, as if this were the sole characteristic of life. "Life," says he, "is owing to an impression made by arterial blood on the brain and spinal marrow, or to the principle which results from this impression;"—a definition which would totally exclude the life of animals that have neither brain, nor spinal marrow, nor arterial blood, nor circulation, which is the case with so large a proportion of beings in the inferior ranks of the animal creation. As an example of the latter error, we may adduce the language of Hunter, who talks of life as the effect of a peculiar and subtile matter, the *materia vitæ diffusa;* a hypothesis analogous to those in natural philosophy, by which the phenomena of matter are attempted to be explained by the intervention of an etherial fluid, diffused throughout all space. To pursue these speculations, would be to wander in the regions of visionary hypothesis, where fancy assumes the garb of science, and where truth is obscured by the clouds of mysticism. The attempt to reduce the vital phenomena to a single law, is as vain as would be a similar endeavour with regard to the phenomena of the inorganic world. The effects of gravitation, electricity, magnetism, cohesion, elasticity, and chemical affinity, have been sometimes regarded as modifications of a single principle of *attraction.* But this is a simplification not warranted by the facts; although future researches may possibly enable us to recognize the identity of some of these principles with others. The recent discovery of Professor Œrsted, indeed, entitles us to hope that such will ere long be the result with regard to electricity and magnetism. In like manner, the muscular, the nervous, the sensorial, and the organic powers, may be established as separate agencies in the living body; and no speculative ingenuity is able to reduce them to a single power; unless, indeed, we call to our aid another and a totally different class of relations, namely, those which they bear to the general object they concur in producing. But against such a substitution of final for physical causes, we have already entered our serious protest. The latter are the only legitimate objects of philosophical analysis, and no other can furnish a solid basis for the physical sciences. This foundation being once firmly established in physiology, subsequent inquiries will consist in the analysis of complex phenomena into the several principles from which they result; and we may then pursue with safety the more fascinating study of final causes, and trace the admirable subordination of purposes, and the skilful combination of means for attaining distant ends, which marks the whole series of phenomena presented to us by living beings.

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PHYSIOLOGY OF VEGETABLES. See VEGETABLE PHYSIOLOGY.

PINDARIES. See INDIA.

PLAYFAIR (JOHN), a Mathematician and Philosopher of great eminence and celebrity; and so peculiarly a benefactor to this publication, as would have made it fit that some memorial of him should be preserved in these pages, even if it could have been surmised that it might not have been found in any other place. There are few names, however, in the recent history of British Science that are more extensively or advantageously known, or of which the few particulars that remain to be recorded will be more generally interesting. His life, like most others that have been dedicated to the silent pursuits of learning and science, does not abound in incidents or adventures; but it is full of honour, both for the individual and the studies to which he was devoted, and may be read with more profit than many more ambitious histories.

He was the eldest son of the Reverend James Playfair, minister of Benvie, in Forfarshire; in which place he was born on the 10th of March 1748. He resided at home, under the domestic tuition of his father, till the age of fourteen, when he entered at the University of St Andrews; and was almost immediately distinguished, not merely for his singular proficiency in mathematical learning, but for the extent of his general knowledge, the clearness of his judgment, and the dignity and propriety of his conduct. A remarkable testimony to this effect has been lately made public in an early Letter of the late Principal George Hill, who was, at this time, one of his fellow students, and was himself so remarkable for early talent, that we find it recorded of him, that he had privately composed an excellent sermon in the tenth year of his age! A youth of this description cannot be supposed to have been very indulgent in his estimate of the merits of his competitors; and it could, therefore, have been no ordinary measure of ability that called forth the following ingenuous avowal, in a confidential Letter to his mother: "Playfair has very great merit, and more knowledge and a better judgment than any of his class fellows. I make *no* exceptions; my parts might be more showy, and the kind of reading to which my inclination led me, was calculated to enable me to make a better figure at St Andrews; but in judgment and understanding I was greatly inferior to him." (Dr Cook's *Life of Principal Hill.*) It is scarcely a stronger, though undoubtedly a very different proof of his rare attainments, that when the Professor of Natural Philosophy, Wilkie, the once celebrated author of the *Epigoniad,* was prevented by indisposition from delivering the regular lectures, he used generally to delegate the task of instruction to his youthful pupil. Wilkie, besides being a scholar and philosopher of no mean note, was a man of primitive benevolence and integrity, and of great vivacity in conversation; and the friendship which, in spite of the disparity of their years, was speedily formed between him and young Playfair, speaks as much for the social and moral character of the latter, as his substitution of him in the class-room does for his early proficiency in science. On this last subject we shall mention but one fact more. In 1766, when only eighteen years of age, he offered himself, with the approbation of his instructors at St Andrews, as candidate for the Professorship of Mathematics in Mareschal College, Aberdeen, and sustained, with the most distinguished credit, an examination or comparative trial, which lasted eleven days, and embraced nearly the whole range of the exact sciences. Out of the six competitors who entered the lists against him, two only were judged to have excelled him,—the Reverend Dr Trail, who was appointed to the office, and Dr Hamilton, who afterwards succeeded to, and has long filled it with much reputation.

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In 1769, he removed to Edinburgh, where his merit and modesty very soon introduced him to the friendship of Dr Robertson—Adam Smith—Dr Mathew Stewart—Dr Black, and Dr Hutton; with all of whom he continued in terms of the utmost cordiality during the whole period of their lives. In 1772, he was a candidate for the Professorship of Natural Philosophy at St Andrews, vacant by the death of his friend Dr Wilkie. There was no comparative trial on this occasion; and he was again unsuccessful —under circumstances, which have led one of the most dutiful sons of that University (Dr Cook, in his *Life of Principal Hill*) to remark, "how much it suffered in thus losing a man, by whose talents its reputation would have been so highly promoted." In the course of the same year, the death of his father suddenly devolved upon him the burden of supporting the family, and admonished him no longer to delay the final election of a profession. He had been educated with a view to the Church, and was every way qualified to accept a living on the establishment; but his decided predilection for science had hitherto made him hesitate about engaging in a vocation, the duties of which, he felt, if conscientiously discharged, would necessarily interfere, to a great extent, with the studies he was loth to abandon. In this emergency, however, he thought himself no longer entitled to indulge in those predilections—and, accordingly, made application to Lord Gray, the patron, for a presentation to the livings of Liff and Benvie, which had been filled by his father. His Lordship was too well aware of his merits to hesitate about conferring so great a benefit on the parishioners; and immediately issued a presentation in his favour, although, from some challenge of his right to the patronage, induction was not obtained till late in the year 1773.

From this period, till 1782, Mr Playfair was constantly resident at Liff, and occupied almost exclusively with the pastoral duties of his office. In this retreat, his leisure hours were dedicated to the education of his younger brothers, and to a very close and intimate correspondence with Mr Robertson (now Lord Robertson), the son of the illustrious historian, to whom he seems to have confided the remarks that occurred to him upon the different authors he perused, and the subjects of speculation which they suggested. We cannot help hoping, that some selection from this correspondence may one day be given to the public. In the year 1779, he contributed to the *Transactions of the Royal Society of London* a paper

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On the Arithmetic of Impossible Quantities, which exhibits, within a very small compass, a striking example of the rare and admirable talent of detaching the sound spirit of science from what may be termed its mysticism, and circumscribing, by the most precise and luminous boundaries, the vague and unlimited inquiries into which many mathematicians had been seduced by the nature of the instruments they employed.

In the year 1782 he was induced, by very advantageous offers, to resign his charge, and to superintend the education of the present Mr Ferguson of Raith, and his brother, Sir Ronald; an arrangement which restored him, in a great measure, to the literary and scientific society of Edinburgh, and enabled him to gratify himself by a personal introduction to several of the most eminent cultivators of science in London. He had repeatedly visited Dr Maskelyne, Astronomer Royal, while that ingenious mathematician was busied, in 1774, in making a series of observations in Perthshire on the attraction of mountains; and while sharing the shelter of his tent on the side of Schehallien, contracted with him a cordial friendship, which continued unbroken for the remainder of their lives. Under these honourable auspices, he made his first appearance in London in 1782, and was speedily introduced to all those in whom he was likely to take most interest. He seems to have kept a pretty full and correct journal of all that he observed during this journey to the metropolis; and a portion of it, which is prefixed to the late collection of his works, is, in our judgment, one of the most interesting parts of that publication. It is not only written with great elegance and accuracy, but affords, in the free, candid, and pointed observations which it contains on the different individuals with whom he comes in contact, a very remarkable proof of his quick and sagacious perception of character, and his power of selecting and turning to account, even in the fever and distraction of a first visit to such a scene, all that was really worthy of careful observation or permanent remembrance.

In 1785 he was received into the University of Edinburgh, in consequence of an arrangement between his two illustrious associates, Dr Adam Ferguson and Mr Dugald Stewart. Mr Stewart exchanged the chair of Mathematics, in which he had succeeded to his father, for that of Moral Philosophy, which had been long filled by Dr Ferguson; who, finding that the delicate state of his health would prevent him from discharging the active duties of the mathematical professor, immediately devolved them upon Mr Playfair, for whom he procured the appointment of joint professor in that department.

In 1788 he published, in the *Transactions of the Royal Society of Edinburgh*, "*A Biographical Account of Dr Matthew Stewart*," which is remarkable, not only for the ease and purity of the style, but also for containing a singularly clear and interesting account of the labours of Dr Simson in the restoration of the ancient geometry, and of the success both of him and Dr Stewart in adapting the elegant simplicity of the Greek methods of investigation to problems which had previously been regarded as insoluble except by the aid of the modern analysis. He also published, in the same year, a paper *On the Causes which affect the Accuracy of Barometrical Measurements*, which is written with all the perspicuity, caution, and sagacity, that constitute the great excellence and the great difficulty of such disquisitions, where scientific principles are employed to give precision to physical observations.

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In 1790 he published in the same *Transactions* a paper of still greater interest and delicacy, *On the Astronomy of the Brahmins*;—a subject which had been recently recommended to the notice of the European scientific world by the curious and learned observations of M. Bailley, in his *General History of Astronomy*, but had never met with so minute and scrupulous an investigation as it now received at the hands of Mr Playfair. The whole treatise is written with a beautiful perspicuity, in an admirable spirit of candour and ingenuity, and in a style more elegant and spirited than had yet lent its attraction to subjects so recondite and abstruse. The publication accordingly attracted very general notice, both in Europe and Asia; and gave rise to much discussion and research, the final value and result of which does not seem to be yet ascertained. This was followed in 1794 by a learned and very beautiful treatise *On the Origin and Investigation of Porisms*, in which the obscure nature of the very comprehensive and indefinite theorems to which this name was applied by the ancient geometers, is explained with the most lucid simplicity; and the extraordinary merits of Dr Simson, in deducing their true theory from the very vague and scanty notices of them which had come down to his time, are commemorated with a noble spirit of emulation.

In 1795 he published his *Elements of Geometry*, for the use of the pupils attending his class; a work which has since been held in such estimation by the public, as to have gone through five editions of 1000 copies each, four of which were called for since the work ceased to be used as a class-book in the University of Edinburgh. In 1797 he composed a sequel to his first paper on the Indian Astronomy, in the shape of *Observations on the Trigonometrical Tables of the Brahmins*; and also a masterly collection of *Theorems on the Figure of the Earth*. It is also understood that he occupied himself a good deal at this time in the preparation of an Essay *On the Accidental Discoveries made by Men of Science while in Pursuit of some other Object*; although we find no portion of this curious discussion in the late collection of his works.

His excellent and ingenious friend Dr Hutton died in the year last mentioned; and Mr Playfair having undertaken to draw up a biographical account of him for the Royal Society, was first led to study his ingenious, but somewhat crude speculations on the Theory of the Earth, and afterwards to lend them the assistance of his own powerful pen in his *Illustrations of the Huttonian Theory*. This work, on which he bestowed more time and labour than on any of his other productions, did not appear till 1802; and it was not till 1803 that he presented to their associates his admirable Memoir of their departed friend.

Whatever opinion may be formed, now or hereaf-

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ter, of the truth or soundness of the suppositions by which Dr Hutton endeavoured to explain the actual state and condition of our globe, it is impossible to doubt that Mr Playfair's illustration of that theory must always be ranked among the most brilliant and powerful productions of philosophic genius. The beautiful clearness, and captivating eloquence, with which the system itself is unfolded and explained—the spirit and force of reasoning with which all the objections to it are combated—the skill with which the infinite variety of facts which it brought into view are combined into one grand and legitimate induction—and the judgment and extent of learning by which so many large and profound views of nature are brought to bear upon the points in discussion, and blended into one large and discursive argument, uniting the utmost logical precision with the richest variety of topics, and the highest graces of composition—are merits which have been universally acknowledged in this performance, even by those who have not been convinced by its reasonings—and have extorted, even from the fastidious critics of France, the acknowledgment that "Mr Playfair writes as well as Buffon, and reasons incomparably better."

The biographical account of Dr Hutton is by far the best of Mr Playfair's productions in this line, and contains not only an eloquent and luminous account of the speculations in which he was engaged, but what is too often forgotten in this species of biography, a charming portrait of the individual—drawn, no doubt, by a favourable hand, but gaining far more in grace and effect than it can possibly have lost in correctness, from the softening colours of affection.

In 1805 he quitted the chair of Mathematics to succeed Professor Robison in that of Natural Philosophy. The appointment of Mr Leslie, as his successor in the chair of Mathematics, was opposed at the time by a majority of the Presbytery of Edinburgh, and made the subject of very angry discussion, as well in various publications as in the General Assembly of the Church of Scotland. From both these fields of contention the opponents of Mr Leslie retired discomfited, and in the opinion, we believe, of many of the lookers on, disgraced. Among the heaviest blows they had to sustain were those that parted from the hand of Mr Playfair. He first addressed a Letter to the Lord Provost, in which, after asserting, with infinite spirit and freedom, the dignity of the science in question, he openly imputes the new sprung zeal for orthodoxy, which had prompted the attack on Mr Leslie, to a wish or design on the part of some of the clergymen of Edinburgh to obtain for themselves a number of the chairs in that University, which had hitherto afforded sufficient occupation to the undistracted industry of laymen: and when this denunciation brought upon him a series of acrimonious and unhandsome attacks, he replied to them all in a pamphlet of greater bulk, written in a style of which the high polish and elegance only serve to give a keener edge to the unsparing severity of the exposures which it conveys.* We do not know, indeed, where to find a more perfect model of polemical or controversial writing; and much as it was to be regretted that an occasion should have arisen for employing such a pen and such a mind as Mr Playfair's on any temporary or personal theme, it is impossible not to admire the extraordinary talent and vigour with which, when the occasion did arrive, he could turn talents, exercised in far other studies, to the purposes suggested by the emergency.

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In 1807 he was elected a Fellow of the Royal Society of London, and soon after presented to that learned body his *Lithological Survey of Schehallien.* In 1809 he contributed to the Edinburgh *Transactions* an excellent paper *On Solids of the greatest Attraction,* and in 1812, another *On the Progress of Heat in Spherical Bodies.*

In 1814 he published, in two volumes 8vo, for the use of his class, an elementary work of great value, under the title of *Outlines of Natural Philosophy.* For some years before this, he had been much occupied in digesting the plan and collecting the materials for a greatly enlarged edition of his *Illustrations of the Huttonian Theory;* with a view to which, he had not only carefully perused and extracted a vast body of voyages and travels, but had made various journeys, and very minutely examined almost all the places in the British dominions, the structure of which promised to throw any light on the subject of his researches. No part of the work, however, was actually written, when the preparation for it was suspended by his being induced to draw up for this publication an introductory *Dissertation on the Progress of Mathematical and Physical Science,*—a treatise which, though its author had written nothing else, would itself suffice to carry his name down with distinction to the latest posterity. The soundness of judgment—the beauty of the writing—the extent of knowledge—the candour and precision of the estimates of character, and the noble spirit of liberality and generous admiration for genius which breathes through the whole performance, give it an attraction which is rarely to be found in works of the same erudition, and renders it not only one of the most instructive, but one of the most interesting publications that philosophy has ever bestowed on the world.

In 1815 he drew up for the Royal Society of Edinburgh a very interesting Memoir of his distinguished predecessor Dr John Robison—a philosopher in whose early life there was more adventure, and in his later days more political prejudice, than we usually find to diversify the history of men of science. Nothing can be more spirited and interesting than Mr Playfair's account of the former—nothing more manly and tender than his reluctant but decided protestation against the excesses of the latter.

* This piece is entitled, *Letter to the Author of the Examination of Mr Stewart's Short Statement of Facts relative to the Election of Professor Leslie,* 8vo, Edinb. 1806. It has not been reprinted in the recent collection of his works.

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After the general peace, in 1815, had at last opened the Continent to British inquirers, Mr Playfair, at the age of sixty-eight, undertook a long journey through France and Switzerland into Italy, and did not return for a period of nearly eighteen months. His principal attention was directed to the mineralogical and geological phenomena of the different regions which he visited, and he made many notes with a view to the great object, which he was not destined to accomplish, namely, the extension and new modelling of his *Illustrations of the Huttonian Theory*. Every object of liberal curiosity, however, had for him an attraction as fresh as in his earliest youth, and the social simplicity and benevolence of his character and manners insured him a favourable reception in every new society to which he was introduced.

On his return from this expedition, he employed himself chiefly in preparing the Second Part of the *Dissertation* to which we have alluded; and he also drew up a *Memoir on the Naval Tactics of Mr Clerk of Eldin*, which was published after his death in the *Philosophical Transactions*, though only a fragment of a projected life of Mr Clerk which he did not live to complete. His health had been occasionally broken for several years by the recurrence of a painful affection of the bladder, which appeared with increased severity in the early part of 1819, but was so far got under as to enable him to complete his course of lectures in the spring. It returned, however, in a still more distressing form in the summer, and at last put a period to his life on the 19th of July. Though suffering great pain during the last part of his confinement, he retained not only his intellectual faculties quite unimpaired, but the serenity and mildness of his spirits, and occupied himself till within a few days of his death in correcting the proof sheets of the *Dissertation*; the printing of the Second Part of which had commenced sometime before his last illness. *

Before concluding these notices of Mr Playfair's scientific and literary labours, we have still to mention, that, from the year 1804, he was a frequent contributor to the *Edinburgh Review*, and that, though most of his articles were of a scientific description, he occasionally diverged into the field of general literature, or indulged in the refinements of metaphysical speculation. Many of his scientific articles attracted great attention on the Continent as well as at home; and several of them are written with a force and beauty that might well entitle them to a higher place than the pages of a periodical publication. There is no general account of the great facts and principles of astronomy, so clear, and comprehensive, and exact, nor *half* so beautiful and majestic in the writing, as his account of La Place's *Mecanique Celeste*, in the eleventh volume of the publication just mentioned.

In this brief sketch of the events of Mr Playfair's life, we have purposely omitted any general account either of his personal character, or of the distinguishing features of his intellectual powers and habits; thinking it better to give those by themselves, in the words in which they were recorded, to the satisfaction, we believe, of most of those who knew him intimately, in a periodical Journal which appeared a short time after his death. The portrait there given has been pronounced by one of the earliest and most illustrious of his surviving friends, "a faithful and perfect resemblance;"† and has accordingly been allowed a place in the prefatory Memoir which his nephew has prefixed to the recent Collection of his Works.

"It has struck many people, we believe, as very extraordinary, that so eminent a person as Mr Playfair should have been allowed to sink into his grave in the midst of us, without calling forth almost so much as an attempt to commemorate his merit, even in a common newspaper; and that the death of a man so celebrated and so beloved, and, at the same time, so closely connected with many who could well appreciate and suitably describe his excellences, should be left to the brief and ordinary notice of the daily obituary. No event of the kind certainly ever excited more general sympathy; and no individual, we are persuaded, will be longer or more affectionately remembered by all the classes of his fellow-citizens; and yet it is to these very circumstances that we must look for an explanation of the apparent neglect by which his memory has been followed. His humbler admirers have been deterred from expressing their sentiments by a natural feeling of unwillingness to encroach on the privilege of those whom a nearer approach to his person and talents rendered more worthy to speak of them,—while the learned and eloquent among his friends have trusted to each other for the performance of a task which they could not but feel to be painful in itself, and not a little difficult to perform as it ought to be; or perhaps have reserved for some more solemn occasion that tribute for which the public impatience is already at its height.

"We beg leave to assure our readers that it is merely from anxiety to do *something* to gratify this natural impatience that we presume to enter at all upon a subject to which we are perfectly aware that we are incapable of doing justice: For of Mr Playfair's scientific attainments,—of his proficiency in those studies to which he was peculiarly devoted, we are but slenderly qualified to judge: But, we believe we hazard nothing in saying that he was one of the most learned mathematicians of his age, and among the first, if not the very first, who introduced the beautiful discoveries of the later continental geometers to the knowledge of his countrymen; and gave their just value and true place, in the scheme of Eu-

* Besides the DISSERTATION, Mr Playfair contributed to this *Supplement* the valuable biographical account of ÆPINUS, and the still more valuable article on Physical ASTRONOMY.

† Letter from Mr Dugald Stewart to Dr Playfair, in the Appendix to the *Biographical Account of Professor Playfair*, prefixed to the Collection of his Works, published at Edinburgh in 1822, in 4 vols. 8vo.

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ropean knowledge, to those important improvements by which the whole aspect of the abstract sciences has been renovated since the days of our illustrious Newton. If he did not signalize himself by any brilliant or original invention, he must, at least, be allowed to have been a most generous and intelligent judge of the achievements of others; as well as the most eloquent expounder of that great and magnificent system of knowledge which has been gradually evolved by the successive labours of so many gifted individuals. He possessed, indeed, in the highest degree, all the characteristics both of a fine and a powerful understanding,—at once penetrating and vigilant,—but more distinguished, perhaps, for the caution and sureness of its march, than for the brilliancy or rapidity of its movements,—and guided and adorned through all its progress by the most genuine enthusiasm for all that is grand, and the justest taste for all that is beautiful in the Truth or the Intellectual Energy with which he was habitually conversant.

"To what account these rare qualities might have been turned, and what more brilliant or lasting fruits they might have produced, if his whole life had been dedicated to the solitary cultivation of science, it is not for us to conjecture; but it cannot be doubted that they added incalculably to his eminence and utility as a Teacher; both by enabling him to direct his pupils to the most simple and luminous methods of inquiry, and to imbue their minds, from the very commencement of the study, with that fine relish for the truths it disclosed, and that high sense of the majesty with which they were invested, that predominated in his own bosom. While he left nothing unexplained or unreduced to its proper place in the system, he took care that they should never be perplexed by petty difficulties, or bewildered in useless details, and formed them betimes to that clear, masculine, and direct method of investigation, by which, with the least labour, the greatest advances might be accomplished.

"Mr Playfair, however, was not merely a teacher; and has fortunately left behind him a variety of works, from which other generations may be enabled to judge of some of those qualifications which so powerfully recommended and endeared him to his contemporaries. It is, perhaps, to be regretted that so much of his time, and so large a proportion of his publications, should have been devoted to the subjects of the Indian Astronomy, and the Huttonian Theory of the Earth. For though nothing can be more beautiful or instructive than his speculations on those curious topics, it cannot be dissembled that their results are less conclusive and satisfactory than might have been desired, and that his doctrines, from the very nature of the subjects, are more questionable than we believe they could possibly have been on any other topic in the whole circle of the sciences. To the first, indeed, he came under the great disadvantage of being unacquainted with the Eastern tongues, and without the means of judging of the authenticity of the documents which he was obliged to assume as the elements of his reasonings; and as to the other, though he ended, we believe, with being a very able and skilful mineralogist, we think it is now generally admitted that that science does not yet afford sufficient materials for any positive conclusion; and that all attempts to establish a Theory of the Earth must, for many years to come, be regarded as premature. Though it is impossible, therefore, to think too highly of the ingenuity, the vigour, and the eloquence of those publications, we are of opinion that a juster estimate of Mr Playfair's talent, and a truer picture of his genius and understanding, is to be found in his other writings;—in the papers, both biographical and scientific, with which he has enriched the *Transactions* of our Royal Society;—his account of Laplace, and other articles which he is understood to have contributed to the *Edinburgh Review*,—the *Outlines* of his *Lectures on Natural Philosophy*,—and, above all, his *Introductory Discourse* to the *Supplement to the Encyclopædia Britannica*, with the final correction of which he was occupied up to the last moments that the progress of his disease allowed him to dedicate to any intellectual exertion.

"With reference to these works, we do not think we are influenced by any national, or other partiality, when we say that he was certainly one of the best writers of his age; and even that we do not now recollect any one of his contemporaries who was so great a master of composition. There is a certain mellowness and richness about his style, which adorns without disguising the weight and nervousness, which is its other great characteristic,—a sedate gracefulness and manly simplicity in the more level passages,—and a mild majesty and considerate enthusiasm where he rises above them, of which we scarcely know where to find any other example. There is great equability, too, and sustained force in every part of his writings. He never exhausts himself in flashes and epigrams, nor languishes into tameness or insipidity; at first sight you would say that plainness and good sense were the predominating qualities; but by and bye, this simplicity is enriched with the delicate and vivid colours of a fine imagination,—the free and forcible touches of a most powerful intellect,—and the lights and shades of an unerring and harmonizing taste. In comparing it with the styles of his most celebrated contemporaries, we would say that it was more purely and peculiarly a *written* style,—and, therefore, rejected those ornaments that more properly belong to oratory. It had no impetuosity, hurry, or vehemence,—no bursts or sudden turns or abruptions, like that of Burke; and though eminently smooth and melodious, it was not modulated to an uniform system of solemn declamation like that of Johnson, nor spread out in the richer and more voluminous elocution of Stewart; nor still less broken into that patch-work of scholastic pedantry and conversational smartness which has found its admirers in Gibbon. It is a style, in short, of great freedom, force, and beauty; but the deliberate style of a man of thought and of learning, and neither that of a wit throwing out his extempores with an affectation of careless grace,—nor of a rhetorician thinking more of his manner than his matter, and determined to be admired for his expression, whatever may be the fate of his sentiments.

"His habits of composition, as we have understood, were not perhaps exactly what might have been expected from their results. He wrote rather slowly,

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—and his first sketches were often very slight and imperfect,—like the rude chalking for a masterly picture. His chief effort and greatest pleasure was in their revisal and correction; and there were no limits to the improvement which resulted from this application. It was not the style merely, or indeed chiefly, that gained by it: The whole reasoning, and sentiment, and illustration, was enlarged and new modelled in the course of it, and a naked outline became gradually informed with life, colour, and expression. It was not at all like the common finishing and polishing to which careful authors generally subject the first draughts of their compositions—nor even like the fastidious and tentative alterations with which some more anxious writers assay their choicer passages. It was, in fact, the great filling in of the picture—the working up of the figured *weft*, on the naked and meagre *woof* that had been stretched to receive it; and the singular thing in his case was, not only that he left this most material part of his work to be performed after the whole outline had been finished, but that he could proceed with it to an indefinite extent, and enrich and improve as long as he thought fit, without any risk either of destroying the proportions of that outline, or injuring the harmony and unity of the design. He was perfectly aware, too, of the possession of this extraordinary power, and it was partly, we presume, in consequence of this consciousness that he was not only at all times ready to go on with any work in which he was engaged, without waiting for favourable moments or hours of greater alacrity, but that he never felt any of those doubts and misgivings as to his being able to get creditably through with his undertaking, to which we believe most authors are occasionally liable. As he never wrote upon any subject of which he was not perfectly master, he was secure against all blunders in the substance of what he had to say; and felt quite assured, that if he was only allowed time enough, he should finally come to say it in the very best way of which he was capable. He had no anxiety, therefore, either in undertaking or proceeding with his tasks; and intermitted and resumed them at his convenience, with the comfortable certainty, that all the time he bestowed on them was turned to good account, and that what was left imperfect at one sitting might be finished with equal ease and advantage at another. Being thus perfectly sure both of his end and his means, he experienced, in the course of his compositions, none of that little fever of the spirits with which that operation is so apt to be accompanied. He had no capricious visitings of fancy which it was necessary to fix on the spot or to lose for ever,—no casual inspiration to invoke and to wait for,—no transitory and evanescent lights to catch before they faded. All that was in his mind was subject to his control, and amenable to his call, though it might not obey at the moment; and while his taste was so sure, that he was in no danger of overworking any thing that he had designed, all his thoughts and sentiments had that unity and congruity, that they fell almost spontaneously into harmony and order; and the last added, incorporated, and assimilated with the first, as if they had sprung simultaneously from the same happy conception.

"But we need dwell no longer on qualities that may be gathered hereafter from the works he has left behind him. They who lived with him mourn the most for those which will be traced in no such memorial; and prize far above those talents which gained him his high name in philosophy, that personal character which endeared him to his friends, and shed a grace and a dignity over all the society in which he moved. The same admirable taste which is conspicuous in his writings, or rather the higher principles from which that taste was but an emanation, spread a similar charm over his whole life and conversation; and gave to the most learned Philosopher of his day the manners and deportment of the most perfect Gentleman. Nor was this in him the result merely of good sense and good temper, assisted by an early familiarity with good company, and a consequent knowledge of his own place and that of all around him. His good breeding was of a higher descent; and his powers of pleasing rested on something better than mere companionable qualities. With the greatest kindness and generosity of nature, he united the most manly firmness, and the highest principles of honour,—and the most cheerful and social dispositions, with the gentlest and steadiest affections. Towards women he had always the most chivalrous feelings of regard and attention, and was, beyond almost all men, acceptable and agreeable in their society,—though without the least levity or pretension unbecoming his age or condition: And such, indeed, was the fascination of the perfect simplicity and mildness of his manners, that the same tone and deportment seemed equally appropriate in all societies, and enabled him to delight the young and the gay with the same sort of conversation which instructed the learned and the grave. There never, indeed, was a man of learning and talent who appeared in society so perfectly free from all sorts of pretension or notion of his own importance, or so little solicitous to distinguish himself, or so sincerely willing to give place to every one else. Even upon subjects which he had thoroughly studied, he was never in the least impatient to speak, and spoke at all times without any tone of authority; while, so far from wishing to set off what he had to say by any brilliancy or emphasis of expression, it seemed generally as if he had studied to disguise the weight and originality of his thoughts under the plainest form of speech and the most quiet and indifferent manner: so that the profoundest remarks and subtlest observations were often dropped, not only without any solicitude that their value should be observed, but without any apparent consciousness that they possessed any. Though the most social of human beings, and the most disposed to encourage and sympathise with the gaiety and joviality of others, his own spirits were in general rather cheerful than gay, or at least never rose to any turbulence or tumult of merriment; and while he would listen with the kindest indulgence to the more extravagant sallies of his younger friends, and prompt them by the heartiest approbation, his own satisfaction might generally be traced in a slow and temperate smile, gradually mantling over his benevolent and intelligent features, and lighting up the countenance of the Sage with the expression of the

mildest and most genuine philanthropy. It was wonderful, indeed, considering the measure of his own intellect, and the rigid and undeviating propriety of his own conduct, how tolerant he was of the defects and errors of other men. He was too indulgent, in truth, and favourable to his friends; --and made a kind and liberal allowance for the faults of all mankind,--except only faults of baseness or of cruelty,--against which he never failed to manifest the most open scorn and detestation. Independent, in short, of his high attainments, Mr Playfair was one of the most amiable and estimable of men,--delightful in his manners,--inflexible in his principles, and generous in his affections, he had all that could charm in society or attach in private; and while his friends enjoyed the free and unstudied conversation of an easy and intelligent associate, they had at all times the proud and inward assurance that he was a being upon whose perfect honour and generosity they might rely with the most implicit confidence, in life and in death,--and of whom it was equally impossible, that, under any circumstances, he should ever perform a mean, a selfish, or a *questionable* action, as that his body should cease to gravitate or his soul to live!

"If we do not greatly deceive ourselves, there is nothing here of exaggeration or partial feeling,—and nothing with which an indifferent and honest chronicler would not concur. Nor is it altogether idle to have dwelt so long on the personal character of this distinguished individual: For we are ourselves persuaded, that this personal character has done almost as much for the cause of science and philosophy among us as the great talents and attainments with which it was combined,—and has contributed in a very eminent degree to give to the better society of this our city that tone of intelligence and liberality by which it is so honourably distinguished. It is not a little advantageous to philosophy that it is in fashion,—and it is still more advantageous, perhaps, to the society which is led to confer on it this apparently trivial distinction. It is a great thing for the country at large,—for its happiness, its prosperity, and its renown,—that the upper and influencing part of its population should be made familiar, even in its untasked and social hours, with sound and liberal information, and be taught to know and respect those who have distinguished themselves for great intellectual attainments. Nor is it, after all, a slight or despicable reward for a man of genius to be received with honour in the highest and most elegant society around him, and to receive in his living person that homage and applause which is too often reserved for his memory. Now, those desirable ends can never be effectually accomplished, unless the manners of our leading philosophers are agreeable, and their personal habits and dispositions engaging and amiable. From the time of Hume and Robertson, we have been fortunate in Edinburgh in possessing a succession of distinguished men, who have kept up this salutary connection between the learned and the fashionable world; but there never, perhaps, was any one who contributed so powerfully to confirm and extend it, and that in times when it was peculiarly difficult, as the lamented individual of whom we are now speaking; and they who have had the most opportunity to observe how superior the society of Edinburgh is to that of most other places of the same size, and how much of that superiority is owing to the cordial combination of the two aristocracies, of Rank and of Letters,—of both of which it happens to be the chief provincial seat,--will be best able to judge of the importance of the service he has thus rendered to its inhabitants, and through them, and by their example, to all the rest of the country." (G. G.)

POLARISATION OF LIGHT. See REFRACTION, DOUBLE.

POLAR SEAS.

THE rapid progress which has been made within the last half century in physical science and geography, has thrown a deeper interest on whatever concerns the Polar Regions, than belongs to the mere commercial speculation in which originated the earliest attempts for discovering a passage through the North Polar Ocean to India and China. It is not here intended, however, to enter into any detail concerning the new objects of natural history, the atmospherical phenomena of temperature, electricity, and magnetism, and various other points of scientific research, which the late expeditions have been the means of collecting and communicating; but to exhibit a sketch of the various attempts which have been made to explore those regions of darkness, long supposed not only to be uninhabitable, but unapproachable; and to take a very concise view of the progressive discovery and geographical information which have resulted from those attempts.

NORTH POLAR SEA.

Boundaries and Extent of the North Polar Sea.

We are now able to draw, with nearly geographical accuracy, the boundaries of the North Polar Sea. A very large portion of the northern shores of Europe, Asia, and America, which circumscribe it, have been visited; and the position of most of their bays, headlands, and rivers, geographically ascertained. By casting our eye over the North Polar Chart, it will be seen that the Polar Sea of that hemisphere is an immense circular basin, which communicates with the two great Oceans of the world, the Atlantic and the Pacific, by two channels, the one separating America from Europe, the other America from Asia. It will be seen, that few points of the coasts of Europe and Asia, which occupy a full half of the circumscribing circle, extend much beyond the 70th parallel of latitude; and all these points have been passed by water, though at different times and by different persons, with the single exception of the

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Cape Cevero Vostocknoi, which, on the charts, is made to extend to the latitude $75\frac{1}{2}°$. The northern coast of America, with Old Greenland, and the two channels above mentioned, complete the circle; America extending about 80° of longitude, or just two-ninths of the whole circle; and of this portion three several points have been ascertained: Icy Cape by Captain Cook; the mouth of Mackenzie River by him whose name it bears; and of the Copper Mine River incorrectly by Hearne; and from these positions it may be concluded, that the average of the latitude of this coast is about the same as, or rather lower than, that of Europe and Asia. The extent, therefore, of the North Polar Sea may be considered about 2400 geographical miles in diameter, or 7200 in circumference.

Islands of this Sea.

The interior or central parts of this sea are very little known. Several islands are scattered over its southern extremities, the largest of which is Old Greenland, whose northern limit has not yet been passed; the others are, Spitzbergen, Nova Zembla, the islands of Liakhov, or, as some have been pleased to call them, New Siberia; the North Georgian islands of Parry, and those which form the western land of Baffin's Bay. Besides these, there are a number of small alluvial islands formed at the mouths of the several rivers of the two continents; but whether any, or what number of islands may exist nearer to the Pole, we must of course remain ignorant till the Polar Sea has been further explored.

Object of Early Voyages to the North.

For that little which is known of this sea, we are indebted to that spirit of discovery which showed itself immediately after a passage to the Indies had been effected round the Cape of Good Hope; not so much, it is true, for the sake of geographical discovery, as that of shortening the passage by sea to the eastern parts of the world. It was obvious that, if a ship could proceed from the Atlantic to the Pacific, on a great circle of the sphere, or nearly so, the distance, compared with the circuitous passage round Southern Africa or Southern America, would be prodigiously shortened. The voyage of Columbus had that object; but it was soon discovered, that, from the Straits of Magellan to the Gulf of St Lawrence, there was one uninterrupted continuity of land. Of the northern regions, the information has been scanty and discouraging for such an enterprise. One of the Scandinavian pirates had indeed been driven by stress of weather, so early as the middle of the ninth century, upon an island to the north-west, to which, from its appearance, he gave the name of Snowland, which was afterwards changed to that of Iceland by the leader of the Norwegian colonists who took refuge on that inhospitable spot; but it was not till more than a century after this that Eric Rauda discovered the southern part of Old Greenland; and there are grounds for believing that, in the year 1001, some of these colonists discovered Newfoundland and the coast of Labrador.

Iceland, Greenland, &c. Discovered.

The Greenland Colonies.

The colony of Iceland continued to flourish in spite of the storms and tempests, the chilling temperature, the earthquakes and volcanoes, which shook to its centre this *Ultima Thulè* of the inhabitable world; but the Greenland colonies were less fortunate. For some time that on the west is said to have so well succeeded as to number one hundred villages, divided into four parishes; but that, having engaged in hostilities with the natives, whom they named *Skrælings* (the same people as the present Eskimaux), the latter compelled them to abandon their settlements. The eastern colony is supposed to have shared a more deplorable fate; a stream of ice having fixed itself to the coast, about the year 1406, and rendered the whole of it, from that time to this, utterly inaccessible. The existence, however, of any such colony, has of late years been called in question; and it is now supposed that all the Danish and Norwegian settlements were confined to the western side of Cape Farewell.

The Voyages of Nicolo and Antonio Zeno.

The voyages and adventures of the two brothers Nicolo and Antonio Zeno in 1380, though they added but little to the knowledge of northern geography, are extremely curious, and throw considerable light on the state of Greenland, Labrador, and the Feroe Islands (Friesland), at that early period. It may be doubted, however, if any of the voyages hitherto made were undertaken for purposes of discovery and the benefit of navigation. The Portuguese have unquestionably the merit of being the first to send out expeditions with these views; and it is to their successful discovery of a passage round the Cape of Good Hope, that we owe the bold enterprise of Christopher Colon, better known as Columbus, to find out a passage to the Indies by steering directly to the west.

Of the Portuguese.

Of John Cabota.

It was not till the year 1496 that England engaged in nautical discoveries. In that year, Henry VII. encouraged John Cabota, a citizen of Venice, to make discoveries, by granting him a patent to search for unknown lands, and to conquer and settle them. His son Sebastian, either alone or in company with his father, discovered Newfoundland, to which was given the name of *Prima Vista*, "the first seen." We say *discovered;* for although the testimonies are in favour of the Scandinavians having settled colonies on this island, no vestige then remained or has since been found of any such colonies. The object of the voyage was, as stated by himself, that, "understanding, by reason of the sphere, that if I should sail by way of north-west, I should by a shorter tract come into India, I thereupon caused the king to be advertised of my devise, who immediately commanded two caravels to be furnished with all things appertaining to the voyage." He states in his report that he reached the 56th degree, but finding no opening in the coast, he despaired of a passage, and returned.

Of the Cortereals.

A claim, however, has been set up for the discovery of *Terra de Bacalhaos* (the Land of Codfish), afterwards called Newfoundland, by John Vaz Costa Cortereal, a Portuguese gentleman belonging to the household of the Infanta Don Fernando, who is said to have touched at that island in the year 1463 or 1464, in an attempt to find a route to India and the Spice Islands by sailing westward round the northern extremity of America. This claim rests on the testimony of Cordeira, and on a patent commission, granting to Cortereal the Captaincy of Terceira, in 1464, as a reward for his important discovery. The

Portuguese certainly not only fished on the banks, but formed establishments on the island of Newfoundland towards the end of the fifteenth century.

In the summer of 1500, two ships sailed from Lisbon, under the command of Gaspar Cortereal, on northern discovery. According to Ramusio, they arrived at a region of extreme cold; and in the latitude of 60° north, discovered a river filled with ice, to which they gave the name of Rio Nevado, that is, Snow River. This land was Labrador, which on an old chart is named Corterealis. In returning, he discovered the Gulf of St Lawrence. Gaspar Cortereal was so satisfied of the existence of a north-west passage to India, that he again left Lisbon, in May 1501, with two vessels, but his own was separated on the coast of Terra Verde, and never more heard of. A second brother went out the following year, but his ship was also supposed to be lost and all hands perished. A third expedition was sent out in search of the unfortunate navigators, but no tidings could be obtained of their fate.

Of Auberton Cartier.

The French are the only maritime people who have seen, with apparent indifference, the exertions made by other nations for the discovery of a passage to India, either by the north-east or the north-west. Auberton Cartier's voyages to Newfoundland and the Gulf of St Lawrence, between 1508 and 1534, can hardly be considered as voyages of discovery; and the subsequent voyages of Roberval and of the Marquis de la Roche had no other object than the discovery of gold, or of a desirable spot to establish a colony on the coast of America.

Of Estevan Gomez.

In the year 1524, the jealousy of the Spaniards would seem to have taken the alarm at the attempts which were making by other nations to discover a shorter way to China and the Indies by the north; for it appears, that a skilful navigator, who had been with Magelhanes, of the name of Estevan Gomez, sailed in that year from Corunna, with the view of discovering a northern passage from the Atlantic to the Moluccas. Gaspar, the only author who has recorded this voyage, enters into no details, but it is supposed he reached no farther than the coast of Labrador, from whence he brought away some of the natives. On his return, he was asked by a friend what success he had met with? The answer was *esclavos* (slaves), which the inquirer mistook for *clavos* (cloves), and spread the report of his having made, as Purchas calls it, a "spicy discovery." It is evident, however, that his voyage was a complete failure, of which, as the voluminous compiler just mentioned observes, "little is left us but a jest."

Of the Spaniards on the West Coast of America.

The alarm of the Spaniards spread to the Pacific; and Cortez, the conqueror and Viceroy of Mexico, on receiving intelligence of the voyages of the Cortereals, fitted out three ships, under the orders of Francisco Ulloa, to look for the supposed Strait of Anian, through which they were to pass. In 1542, the Viceroy Mendoza sent one expedition by land and another by sea from Mexico to the northward. No discoveries were made by any of these voyages. Two years after this, the Court of Spain ordered another expedition along the western coast of America, the conduct of which was entrusted to Juan Rodriques de Cabrillo, a Portuguese in the service of Spain. He reached the latitude of 44° N. and gave the name of Cape Mendocino to the land, about the latitude 42° N., in compliment of the viceroy.

First English Voyage.

England, in the mean time, was not inactive. At the suggestion of Mr Robert Thorne of Bristol, King Henry VIII. caused to be sent forth "two faire ships, with divers cunning men, to seek strange regions," which left the Thames in 1527. All that Hakluyt could discover of these ships and the cunning men was, that the name of one of them was Dominus Vobiscum, and that a canon of St Paul's of London, a great mathematician and wealthy man, went on the expedition. One of these ships was cast away in the great opening between the north parts of Newfoundland and Meta Incognita, supposed to be Greenland.

Second English Voyage.

In the year 1536, two ships, the Trinitie and the Minion, were set forth by Master Hore of London, "a man of goodly stature and of great courage, and given to the studie of cosmographie." Six score persons, we are told, embarked on this expedition, whereof thirty were gentlemen. They reached no higher than Newfoundland; but there is a curious account of their proceedings by Hakluyt, which he procured from Mr Oliver Dawbeny, merchant of London, who was one of the adventurers on board the Minion.

Voyage of Sir Hugh Willoughby.

On the return of Sebastian Cabot to England, he was constituted Grand Pilot, and "Governor of the Mysterie and Companie of the Merchants Adventurers for the Discoverie of Regions, Dominions, Islands, and Places unknown." At his suggestion, a voyage was undertaken, in the year 1553, for the discovery of a *north-east* passage to Cathaia, consisting of three vessels, whose crews, including eleven merchants, amounted to 113 persons. Numerous candidates stood forward for the command of this expedition; but Sir Hugh Willoughby was appointed Captain-General of the fleet, "both by reason of his goodly personage (for he was of tall stature), as also for his singular skill in the services of warre." The fate of this expedition was most disastrous. Sir Hugh Willoughby, with his brave associates, as well as the crew of the second ship, to the number of seventy persons, miserably perished, from cold and hunger, on the coast of Lapland, at the mouth of a river called Arzina, not far from the harbour of Kegor. The third ship, under Master Richard Chancelor, had parted company, and by putting into Wardhuys, in Norway, escaped the fate of his companions; and in the following year, discovered the port of Archangel, and opened the first intercourse with Russia.

Of Stephen Burrough.

In the years 1555 and 1556, two ships were sent out to Archangel, to carry Commissioners to the Court of Moscow, and having landed them to prosecute discoveries, and "to use all wayes and meanes possible to learne howe men may passe from Russia, either by land or sea, to Cathaia." Stephen Burrough, in the Serchthrift, proceeded easterly as far as the island of Waygatz, where he was stopped by the constant north-east and northerly winds, thick weather, and abundance of ice. The neighbouring

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country was inhabited by *Samoeds*, who had no houses, but tents made of deers' skins.

Of Martin Frobisher.

The rapid progress made from this time by land through Russia to Persia and India, revived the ardour for discovery by sea, and the pens of the most learned and ingenious men in the nation were employed to prove the existence, the practicability, and the great advantages which would result from the discovery of a north-west passage. Among others, Martin Frobisher had laboured for fifteen years, but without the means of setting forth an expedition, till at last, in the year 1576, by the assistance of Dudley Earl of Warwick, and a few friends, he was enabled to fit out two small barks, the Gabriel of 35, and the Michael of 30 tons, and a small pinnace of 10 tons. On the 11th July, this little squadron came in sight of Friesland, " rising like pinnacles of steeples, and all covered with snow." This Friesland, being in 61° latitude, was probably the southern part of Old Greenland. He entered a strait, which now bears his name, in latitude 63° 8′ N., and had communication with the Eskimaux, whom he describes as " like to Tartars, with long black hair, broad faces, and flatte noses." He brought home one of these " strange infideles, whose like was never seene, read, nor heard of before;" and Frobisher had the satisfaction to find himself " highly commended of all men for his greate and notable attempt, but speceally famous for the great hope he brought of the passage to Cathaia."

His Second Voyage.

Some of the crew having brought home a stone which " glistend with a bright marquesset of gold," Queen Elizabeth now gave countenance to a second attempt, and added to the expedition " one tall ship of hir Majesties, named the Ayde." In this voyage they proceeded to Mount Warwick, on Resolution Island, in latitude 63½° N., from whence they sailed on their return home on the 22d August, having lost only one man by sickness, and another who fell overboard.

His Third Voyage.

Though Frobisher brought home neither gold nor silver, but something which had the appearance of both, the Queen and her Court pleased in " finding that the matter of the gold ore had appearance, and made shew of great riches and profit, and the hope of the passage to Cathaia by this last voyage greatly increased," determined to establish a colony on Meta Incognita; for which purpose fifteen ships were prepared, carrying 100 persons to form the settlement; with whom three of the ships were to remain, and the other twelve to bring back cargoes of gold ore. The fleet sailed on the 31st May 1578; part of it entered Frobisher's Strait, and part were driven towards the coast of Greenland. On the 30th August, the ships having re-assembled off Hatton's Headland, on Resolution Island, and all hands disheartened by the cold and tempestuous weather, they resolved to make sail for England, where they all arrived at different ports about the beginning of October, with the loss, by deaths, of about forty persons.

Of Pet and Jackman.

The progress made by land to the eastward induced the Russia Company to fit out two ships, under the command of Pet and Jackman, to make another attempt at a north-east passage. They left Harwich on the 30th May 1580, reached Wardhuys on the 23d June, and the coast of Nova Zembla the 16th July; passed the Strait of Waygatz, but were obliged to return on account of the ice.

Of Sir Humphry Gilbert.

Sir Humphry Gilbert and his brother obtained from Queen Elizabeth, in 1578, a patent for making western discoveries, by which they established a corporation under the name of " The Colleagues of the Fellowship for the Discoverie of the North-west Passage." In 1583, Sir Humphry set out to take possession of Newfoundland, but the voyage was most disastrous, and on his return, his little bark foundered at sea, when he and all that were in her perished.

Of John Davis.

In 1585, John Davis was sent out by the merchants of London, for the discovery of the north-west passage. Two barks, the Sunshine and the Moonshine, one of 50, the other of 35 tons, were fitted out for this purpose. On the 6th of August, Davis had proceeded so high up the strait which now bears his name as latitude 66° 40′, and anchored in Exeter Bay, under " a brave mount," to which he gave the name of " Mount Raleigh, the cliffs whereof were as orient as gold." On the 8th August, they returned to the southward, and arrived in Dartmouth the 30th September.

His Second Voyage.

In 1586, Davis set sail a second time, and coasted the western shore of Greenland up to the latitude 66° 33′, stood from thence across to the westward, made the land in 66° 19′, and turning to the southward, along the coast and numerous islands, anchored in a bay on the coast of Labrador, in latitude 56°, and, sailing from thence, arrived in England in the month of October.

His Third Voyage.

A third voyage being determined on, Davis sailed from Dartmouth on the 19th May, made the land on the west coast of Greenland in latitude 64° on the 14th June, had advanced as high as latitude 67° on the 24th, and, on the 30th, was in latitude 72° 12′. From hence he crossed to the westward in an open sea, but being driven, as he supposed, by a current, found themselves, on the 19th, abreast of Mount Raleigh. After this, Davis advanced 60 leagues up the strait he had discovered on the former voyage, now called Cumberland Strait; passed through Lumley's Inlet, the same, it is supposed, which Frobisher had discovered, and known as Frobisher's Strait; and, standing to the south-east, discovered Cape Chidley, and, returning homewards, arrived in England by the middle of September. *

Of the voyage of Maldonado in 1588, and of Jan-de Fuea, 1592, it is not necessary to say any thing, the latter being at best but problematical, and the former altogether spurious.

Voyages of William Barentz.

The next attempts we find in chronological order were three voyages for the discovery of a north-east passage, undertaken by the Dutch, in which William Barentz was chief pilot. The first of these was

* An interesting account of the proceedings of this able and intrepid navigator, by himself, is contained in a very rare and curious little book called *The Worlde's Hydrographical Description*, 1595.

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set forth in 1594; proceeded easterly as far as Waygatz, then along the western coast of Nova Zembla as high as latitude 77° 25′, and returned to the Texel the 16th September. On the second voyage, the following year, they did not reach Nova Zembla till the 17th August, when finding it impossible, on account of the great quantity of ice, and "the weather being misty, melancholic, and snowie," they returned to the westward, and arrived in the Macs on the 18th November.

The third voyage of Barentz is intensely interesting. The ships left the Texel in May, and on the 9th June, after sailing among much ice, they discovered Bear (since called Cherry) Island. Proceeding northerly, they discovered Spitzbergen, along the western coast of which they had advanced, on the 19th, as high as 80° 11′, opposite the point since known as Hakluyt's Headland. Returning to the southward, Barentz made for the coast of Nova Zembla; doubled the northern extremity; and then found himself compelled, by the pressure of the ice and bad weather, to seek for refuge in a small bay, which they called Ice Haven; and here they passed "their cold, comfortlesse, darke, and dreadful winter," in about the 76th parallel of latitude. The ship was wholly wrecked, and the surviving part of the crew, fifteen in number, left this spot the following year in two open boats; and after an exertion of forty days, in which they suffered the greatest fatigue, famine, and cold, and in which Barentz and two others died, they reached Kilduin in Lapland, a distance of 1000 miles and more from the bay in which they had passed the winter.

Of George Weymouth.

The merchants of England seem to have lost all hope of a northern passage to the East Indies, till they were once more roused by a supposed piece of information of Captain James Lancaster, that the passage was in the north-west of America, in latitude 62° 30′. Accordingly in 1602 the Muscovy and Turkey Companies fitted out two fly-boats, the Discovery and Godspeed, the command of which was given to Captain George Weymouth. This voyage, however, was a complete failure. It is difficult to make out precisely the utmost limit at which it arrived; it was not much beyond Resolution Island in Hudson's Strait; but, to use the words of a subsequent sagacious navigator, Luke Fox, "Davis and Weymouth lighted Hudson into his Straits."

Of Hall and Knight.

In 1605, the King of Denmark sent out an expedition of discovery, in which two Englishmen, James Hall and John Knight, were employed. The ships proceeded along the west coast of Greenland, but reached no higher than about latitude 66° 55′; gave the names of Christian's Foord and Queen Anne's Cape; traded and quarrelled with the natives; left two malefactors among them, and returned to Elsineur.

This expedition was followed up by two others in the two following years, neither of which was productive of any discoveries; the first having advanced only to 66° 25′ on the coast of Greenland, and the latter not farther than Cape Farewell.

Of John Knight.

In 1606, the merchants of London sent out the Hopewell, under the directions of John Knight. In latitude 56° 48′, on the coast of Labrador, Knight, with his mate and four others, went on shore, and were supposed to be murdered by the natives, as none of them were ever afterwards heard of. The ship returned home.

The Voyages of Henry Hudson.

Henry Hudson made no fewer than four voyages of discovery. The first, in 1607, was along the eastern coast of Greenland, when he observed, in 78° 56′, a higher degree of latitude on that coast than has since been ascended. The second, in 1608, was an attempt to the eastward, where, as in all preceding attempts, he was stopped at Waygat Strait. Of the third little is known. Its northern limits appear to have been the North Cape on one side, and Newfoundland on the other.

The fourth voyage was fatal to Hudson; but it opened the way to the coast of America in a higher degree of latitude than it had yet been approached. He left the Thames in the Discovery of 55 tons, on the 17th April 1610; and reached the Isle of Godsmercie, in the strait which bears his name, on the 6th July; on the 2d August, he discovered land, which he named Cape Wolstenholm; and near it, on a cluster of islands, Cape Digges—and here ends Hudson's narrative; for his crew having mutinied, they put Hudson, his son, and seven others, into an open boat, which was never heard of more. The ship returned to England, and, what is most remarkable, the inhuman and atrocious act does not appear to have caused any sensation, nor was any inquiry instituted into the proceedings of the mutineers.

Of Thomas Button.

Two of them, in fact, Abacuk Pricket and Robert Bylot, were employed under Captain (afterwards Sir Thomas) Button, appointed to prosecute the discovery of a north-west passage, in two ships, the Resolution and Discovery. Button followed the tract of Hudson, and succeeded in reaching the coast of America, where he wintered in Nelson's River, in latitude 57° 10′. The following year they stood to the northward, and discovered Southampton Island, as high up as latitude 65°; made some discoveries of Islands, and returned to England in the autumn of 1613.

Of James Hall.

In 1612, we find James Hall employed on an expedition up the western coast of Greenland, where he was slain by one of the natives at Ramel's Point, in latitude 67°. The account of the voyage is written by William Baffin, who was pilot, in which he relates the method of determining the longitude by an observation of the time when the moon came upon the meridian; the first navigator probably who practised this method.

Of Captain Gibbon.

In 1614, Captain Gibbon was sent out in the Discovery, at the recommendation of Sir Thomas Button; he encountered much ice at the opening of Hudson's Strait, returned to the southward, and was shut up in a bay on the coast of Labrador, for five months; and returned without making any progress in the north-western discovery. To this bay the ship's company are said to have given, in derision, the name of "Gibbon's his Hole."

Of Bylot and Baffin.

In 1615, the Discovery was fitted out a fourth time, and the command of her given to Robert By-

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Bylot, who took William Baffin as his mate. They visited Button's Islands, Savage Islands, and Mill Islands, and proceeded along the east coast of Southampton Island to Cape Comfort, in latitude . From hence they returned to the southward, and reached England in the month of September.

In 1616, Bylot and Baffin again set out in the bark Discovery, in search of a north-west passage; and, following their instructions, proceeded up Davis's Strait to Hope Saunderson, the extreme point of Davis's progress, being between 72° and 73° latitude, which they reached as early as the 30th May. A little to the northward was a group of islands, to which, finding females only, they gave the name of Women's Islands. From hence they stood northerly, between the ice and the land, passing in succession Horn Sound, Wolstenholm's Islands, Whale Sound, Sir Thomas Smith's Sound, in latitude 78°, and, at the northern extremity of what has since been called Baffin's Bay; and following the direction of the land, they passed, on the western shore, Alderman Jones's Sound, and lastly, Lancaster Sound; from whence the ice compelled them to leave the land, and they therefore shaped their course homewards. This last voyage of Baffin is the most important that had yet been made; and it is quite surprising that the discovery of so many immense openings which he calls *sounds*, for want of a better word, should not have been followed up, and that not one of them should have been examined until the recent expedition under that intelligent and enterprising officer Captain Parry.

In 1619, the Danes sent out an expedition under Jens Munck, who penetrated as high up on the coast of America as Chesterfield Inlet, which he named Munck's Winter Harbour, for he wintered in it, and all his people, except two, perished of cold, disease, and famine. Munck, and these two survivors, with great difficulty, fitted out the smaller of the two vessels, and reached Denmark, where they were considered as men risen from the dead. Munck is said to have received the indignity of a blow from the King, on which he took to his bed, and died of a broken heart; but there is an air of romance in the account of this voyage, which makes its authenticity doubtful.

Of Luke Fox.

In 1631, Captain Luke Fox, who quaintly calls himself the "North-west Fox," prevailed on some merchants of London to procure from King Charles I. his countenance, and the loan of one of his ships, for attempting the discovery of a north-west passage. Fox was undoubtedly the most shrewd and intelligent of all former navigators; and if, when he reached what he calls Fox's Farthest, he had stood across to the westward, the probability is, that he would have got upon the northern coast of America, and succeeded in working his way into the Pacific, by the very route which Parry is now pursuing.

Of Captain James.

In the same year the merchants of Bristol fitted out the Maria of 70 tons, the command of which was given to Captain James. In proceeding up Hudson's Strait, somewhere about Resolution Island, he got his ship entangled in the ice; and from that spot to Charlton Island, at the bottom of Hudson's Bay, in latitude 52°, he details a series of disasters which never happened to any navigator before or since. Here he passed the winter, and returned the following year, without making the least progress in discovery.

Of Captain Daniel.

In 1652, the King of Denmark again set forth an expedition under Captain Daniel, to explore the *eastern* coast of Greenland. He stood to the northward of Iceland, but he could not approach the land on account of the ice, but the mountains were visible at least 60 miles. The most northern cape seen was in 65° 30′, to which he gave the name of Cape King Frederick. From this point to Cape Farewell the ice lay between him and the shore, which in no part he could approach within 20 miles; of course, no discovery was made by him.

Of Wood and Flaws.

After the lapse of more than a century, a paper admitted into the *Transactions* of the Royal Society of London in 1675, tended to revive the attempt at a north-east passage in England. It contained an account of a Dutch ship fitted out by a company of merchants in Holland, having passed to the north-eastward of Nova Zembla several hundred leagues, between the parallels of 70° and 80°; and the sea in that direction was found to be perfectly open and free from ice. About the same time, it was reported that Spitzbergen had been circumnavigated, and that a Dutch ship had proceeded within one degree of the Pole. Upon the strength of these reports, Captain John Wood addressed a memorial to the king, assigning *seven reasons* and *three arguments*, for the existence of a north-east passage. Accordingly, two ships were fitted out under Captains Wood and Flaws; they left the Nore in May 1676; on the 22d June, had reached the latitude 75° 79′, and on the 26th got sight of the west coast of Nova Zembla. Three days after this, Wood lost his ship among the ice, and after some perils and the loss of two men in reaching the shore, they were picked up by the other ship, and returned homewards without making the least discovery; when Wood published many peremptory and ill-founded reflections on former navigators, and now found out seven reasons and three arguments *against* the passage to the north-east.

Of Captain Middleton.

Of the voyages of Knight, Barlow, Vaughan, and Scroggs, from the Hudson's Bay Company's settlements, along the eastern coast of America, little else need be said, than that they extended not the knowledge of that coast beyond Whale Point; but their observations on the strong tide flowing down the Welcome, induced a gentleman of the name of Dobbs to press the Board of Admiralty to appropriate a ship of the navy to make discoveries in this quarter. Two ships were accordingly fitted out, the Furnace bomb, and the Discovery pink, commanded by Captain Middleton and Mr William Moor. They left England in 1741, and wintered in Churchill River in latitude 58° 56′; remained there till the 1st July; proceeded northerly to the latitude 65° 23′, and entered Wager River, which they examined in an imperfect manner. They then stood to the northward as far as Cape Hope, in latitude 66° 14′, longitude 86° 28′ W.; and, most unaccountably, abandoned all farther search, having

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In 1619, the Danes sent out an expedition under Jens Munck, who penetrated as high up on the coast of America as Chesterfield Inlet, which he named Munck's Winter Harbour, for he wintered in it, and all his people, except two, perished of cold, disease, and famine. Munck, and these two survivors, with great difficulty, fitted out the smaller of the two vessels, and reached Denmark, where they were considered as men risen from the dead. Munck is said to have received the indignity of a blow from the King, on which he took to his bed, and died of a broken heart; but there is an air of romance in the account of this voyage, which makes its authenticity doubtful.

Of Luke Fox.

In 1631, Captain Luke Fox, who quaintly calls himself the "North-west Fox," prevailed on some merchants of London to procure from King Charles I. his countenance, and the loan of one of his ships, for attempting the discovery of a north-west passage. Fox was undoubtedly the most shrewd and intelligent of all former navigators; and if, when he reached what he calls Fox's Farthest, he had stood across to the westward, the probability is, that he would have got upon the northern coast of America, and succeeded in working his way into the Pacific, by the very route which Parry is now pursuing.

Of Captain James.

In the same year the merchants of Bristol fitted out the Maria of 70 tons, the command of which was given to Captain James. In proceeding up Hudson's Strait, somewhere about Resolution Island, he got his ship entangled in the ice; and from that spot to Charlton Island, at the bottom of Hudson's Bay, in latitude 52°, he details a series of disasters which never happened to any navigator before or since. Here he passed the winter, and returned the following year, without making the least progress in discovery.

Of Captain Daniel.

In 1652, the King of Denmark again set forth an expedition under Captain Daniel, to explore the *eastern* coast of Greenland. He stood to the northward of Iceland, but he could not approach the land on account of the ice, but the mountains were visible at least 60 miles. The most northern cape seen was in 65° 30′, to which he gave the name of Cape King Frederick. From this point to Cape Farewell the ice lay between him and the shore, which in no part he could approach within 20 miles; of course, no discovery was made by him.

Of Wood and Flaws.

After the lapse of more than a century, a paper admitted into the *Transactions* of the Royal Society of London in 1675, tended to revive the attempt at a north-east passage in England. It contained an account of a Dutch ship fitted out by a company of merchants in Holland, having passed to the north-eastward of Nova Zembla several hundred leagues, between the parallels of 70° and 80°; and the sea in that direction was found to be perfectly open and free from ice. About the same time, it was reported that Spitzbergen had been circumnavigated, and that a Dutch ship had proceeded within one degree of the Pole. Upon the strength of these reports, Captain John Wood addressed a memorial to the king, assigning *seven reasons* and *three arguments*, for the existence of a north-east passage. Accordingly, two ships were fitted out under Captains Wood and Flaws; they left the Nore in May 1676; on the 22d June, had reached the latitude 75° 79′, and on the 26th got sight of the west coast of Nova Zembla. Three days after this, Wood lost his ship among the ice, and after some perils and the loss of two men in reaching the shore, they were picked up by the other ship, and returned homewards without making the least discovery; when Wood published many peremptory and ill-founded reflections on former navigators, and now found out seven reasons and three arguments *against* the passage to the north-east.

Of Captain Middleton.

Of the voyages of Knight, Barlow, Vaughan, and Scroggs, from the Hudson's Bay Company's settlements, along the eastern coast of America, little else need be said, than that they extended not the knowledge of that coast beyond Whale Point; but their observations on the strong tide flowing down the Welcome, induced a gentleman of the name of Dobbs to press the Board of Admiralty to appropriate a ship of the navy to make discoveries in this quarter. Two ships were accordingly fitted out, the Furnace bomb, and the Discovery pink, commanded by Captain Middleton and Mr William Moor. They left England in 1741, and wintered in Churchill River in latitude 58° 56′; remained there till the 1st July; proceeded northerly to the latitude 65° 23′, and entered Wager River, which they examined in an imperfect manner. They then stood to the northward as far as Cape Hope, in latitude 66° 14′, longitude 86° 28′ W.; and, most unaccountably, abandoned all farther search, having

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seen, or fancied they saw, "a frozen strait" between them and the point round which they had to proceed to the westward. Middleton had been an old servant of the Hudson's Bay Company, who were supposed to be jealous of any discoveries in their neighbourhood, and averse from encouraging them; and he was accused of having taken a bribe from them to defeat the object of the expedition. The Lords of the Admiralty refused to approve of his proceedings, and to evince the feeling of the government, an act was passed the very year after his return, offering a reward of L. 20,000 to the person or persons, being subjects of his Majesty, who should discover a north-west passage through Hudson's Strait to the Pacific. Dobbs, turning these circumstances to the advantage of his favourite project, got up a large subscription, and in 1746, two other vessels were fitted out, and the command of them given to Captain William Moor and Captain Francis Smith. Their first examination was that of the Wager River, which was found to terminate in a broad rapid, beyond which were two unnavigable rivers. They then proceeded northerly, till they came to Captain Middleton's "frozen strait," or opening into Repulse Bay, when a difference of opinion arose among the officers, whether they were authorized by their instructions to examine this bay! The fact appears to be, that the officers and men had no taste for the business, and were under no kind of discipline. Instead, therefore, of proceeding, they began to murmur, and although only the 7th August, they urged the lateness of the season, and wished to return home. After this nothing was done or even attempted; and Repulse Bay remains unexamined to this moment; and what we see laid down in the charts under that name is wholly gratuitous.

Of Moor and Smith.

Of Phipps and Lutwidge.

No farther attempts at either passage appear to have been made by any of the maritime nations for nearly thirty years. But the Honourable Daines Barrington having, in the year 1773, presented to the Royal Society a series of papers on the practicability of approaching the North Pole, the President and Council of that Society made application to the First Lord of the Admiralty (then Lord Sandwich) to send out a ship or ships, to try how far navigation might be practicable towards that quarter. The Racehorse and Carcass bombs were accordingly prepared, and the command given to Captain the Honourable Constantine Phipps and Captain Skiffington Lutwidge. They left the Nore on the 10th June, passed along the western coast of Spitzbergen, and advanced to latitude 80° 48′, in sight of the Seven Islands; here they were beset in the ice on the 1st August, and on the 10th, after being forced through it by a north-east wind, they proceeded to the southward, and arrived at the Nore on the 25th September.

Of Cook and Clerke.

The hopes of a north-west passage were not abandoned by this failure; but it was resolved to make the attempt by a different route to any that had yet been practised; that is to say, from the Pacific to the Atlantic. Captain Cook was selected for this enterprise, and two ships, the Resolution and Discovery, were fitted out for the purpose, the latter being commanded by Captain Clerke. An amended act was passed for granting the reward of L. 20,000 for the discovery of "any northern passage" by sea, between the Atlantic and Pacific Oceans, and also the reward of L. 5000 to any ship which should approach the North Pole within one degree. Captain Cook left England in July 1776; entered Behring's Strait on the 9th August 1779; and on the 17th August, reached latitude 70° 41′ N., and saw the highest point of America surrounded with ice; and, therefore, named by him Icy Cape, in latitude 70° 29′, longitude 198° 20′. The main body of the ice drifting down towards the ships, and the weather becoming foggy, they stood to the southward; and, as the season was far advanced, Captain Cook determined to pass the winter at the Sandwich Islands, and to renew the attempt at an earlier period the following year. By his death at this place, Captain Clerke became the commanding officer. That he should have failed in reaching as far north as Cook had done, is not at all surprising, after an absence of three years from home, and all hands, as is avowed, "heartily sick of a navigation full of danger." A small vessel had been sent, in the year 1776, up Davis's Strait, under Lieutenant Pickersgill, and the same vessel again in 1777, under Lieutenant Young, to render any assistance that might be required, in the event of Captain Cook's reaching Baffin's Bay; but neither of these officers made a progress beyond the 73d degree of latitude.

Admiral Lowenorn

In 1786 and 1787, the King of Denmark, at the suggestion of Bishop Egede, sent out an expedition under Captain (now Admiral) Lowenorn, for the purpose of rediscovering the eastern coast of Greenland. This officer persevered for two years, but with no better success than his predecessors. They saw the coast at various points, as high up as 66½°, but could not approach it for the ice. No discovery, therefore, of importance resulted from this expedition.

On the part of England, all farther attempts appeared to be abandoned after the failure of Captain Cook. One gentleman, however, the late Alexander Dalrymple, Hydrographer to the Admiralty, considering that three points of the northern coast of America had been clearly established,—Icy Cape by Cook; the north of the Copper Mine River, in 1772, by Hearne; and the mouth of Mackenzie River by the traveller whose name it bears, in 1789;—which three points were supposed to be in or about the 70° parallel of latitude, and that they comprehended within them full two-thirds of the whole of that coast; and combining these discoveries with other circumstances, was decidedly of opinion that a north-west passage did exist, and that it was practicable. On the strength of this opinion, he prevailed on the governor of the Hudson's Bay Company to employ Mr Charles Duncan, a master in the navy, on the discovery. He left England for this purpose in 1790, to join a sloop of the name of the Churchill, then in Hudson's Bay; but he soon discovered that the crew were averse from the intended enterprise, and set up so systematic an opposition to proceeding upon it, that he deemed it prudent to leave them, and to return to England. The governors of the company expressed their regret; and to prove how

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much they were in earnest, fitted out a strong ship called the Beaver, and Mr Duncan set out a second time. He wintered in Churchill River, where he remained till the 15th July, and entered Chesterfield Inlet; his crew mutinied, encouraged by his first officer, who was a servant of the Hudson's Bay Company, and thus ended his second voyage.

Of the Russian Voyages.

We have said nothing of the Russian voyages along the northern coast of Asia. That no one person has performed the whole, either at once or by successive trials, is quite clear; but, with the single exception of one "sacred promontory," called Cape Cevero Vostochnoi, between the Yenisei and the Lena, the whole has been navigated by various persons at different times. In the years between 1734 and 1738, Lieutenants Moroviof, Malgyn, and Skurakof, succeeded in proceeding from Archangel to the Bay of Obe; and in the latter year, Offzin and Koskelef proceeded from that bay to the mouth of the Yenisei. In 1735, Lieutenant Prontshistshef set out in the contrary direction from the Lena, but was stopped by the promontory above mentioned; though some affirm that he passed it, and reached as far as Taimura. From the Lena eastward to the Kowyma, the voyage has frequently been performed, and Shalauroff, in 1671, succeeded in reaching the Shelatskoi Noss, but could not double it; and the only instance of its having been passed is that of Deshnef, as far back as the year 1648, who sailed from the Kowyma, through Behring's Strait, to Anadyr.

Of Lieutenant Kotzebue.

The immense distance by sea from Petersburgh to Kamtschatka, and the Russian settlements on the north-west coast of America, would render the discovery of a north-west passage of infinite importance to Russia. Impressed with the magnitude of this importance, an individual of that nation, the Count Romanzoff, fitted out, at his own expence, a small vessel, named the Rurick, the command of which was given to Lieutenant Kotzebue. She left the Baltic in 1815, passed Cape Horn, and in 1817 entered a deep inlet on the eastern side of Behring's Strait, in which he passed the remaining part of the summer. He found no ice, neither in the strait nor the inlet, and saw nothing to prevent his proceeding up the American coast to Icy Cape but the lateness of the season; and therefore returned to the southward, with the intention of renewing the attempt the following year. An accident, however, which occurred on his second entrance of the strait, though personal only, put an end to the expedition.

Of Ross and Parry, Buchan and Franklin.

This voyage of Kotzebue would alone have been sufficient to stimulate England to attempt once more to accomplish the almost only interesting discovery in geography that remains to be made; but other circumstances were reported in the year 1817 which determined the Government to fit out two expeditions for northern discovery. A ship from Hamburgh, in the summer of that year, made the eastern coast of Greenland, which was supposed to have been shut up with ice for four centuries, in the 70th parallel of latitude, continued along it to the 80th degree, and stood along that parallel to the coast of Spitzbergen. For three years before this, the post-office packets, and other vessels crossing the Atlantic, had fallen in with very unusual quantities of ice floating to the southward. This breaking up of the ice was deemed favourable for the prosecution of northern discovery. For this purpose, two separate expeditions were put in preparation. One was intended to proceed by the North Pole, as the nearest route, and, if no interruption from land occurred, probably the most practicable, to Behring's Strait; the other, to attempt a passage by some of the openings leading out of Baffin's Bay. To each were assigned two ships. Those destined for the Polar passage were the Dorothea, of 370 tons, commanded by Captain David Buchan, and the Trent, of 250 tons, by Lieutenant John Franklin. Those for the north-west were the Isabella, of 382 tons, commanded by Captain John Ross, and the Alexander, of 252 tons, by Lieutenant William Edward Parry. The Polar expedition was rendered abortive by the disabling of the Dorothea in the ice; the other circumnavigated Baffin's Bay, and ascertained that the narrative of that able navigator whose name it bears is substantially true; and that the chart appended to the *Voyage of the North-West Fox* is, in fact, the chart of Baffin, and wonderfully correct for the time in which it was laid down. Not one, however, of the many great openings which appear in that chart, and were ascertained to exist, were examined; and the only one that was entered was abandoned in a most unaccountable manner, and on grounds which were at once suspected, and subsequently proved, to be utterly without foundation.

Of Parry and Liddon.

Another expedition was, therefore, immediately fitted out, consisting of two ships, the Hecla bomb and Griper gun-brig, and the command of it given to Lieutenant Parry, Lieutenant Liddon being appointed to that of the Griper. They dropped down the river on the 4th May 1819; saw Cape Farewell on the 15th June; and by the 30th July had succeeded in crossing the ice of Baffin's Bay, and reaching the opening of Sir James Lancaster's Sound; just one month earlier than in the preceding year. To the examination of this sound Mr Parry was particularly directed by his instructions. In proceeding along it to the westward, he met with little obstruction from the ice (though he was evidently navigating through an archipelago of islands where it usually most abounds), until he came to the western extremity of what he calls Melville Island; the last that was visible on the northern side of the strait or passage through which he had proceeded. Beyond this he struggled in vain, till the 20th September, to get to the westward, when the severity of the weather made it prudent to look out for a secure spot to pass the winter; and after cutting a canal through the ice upwards of two miles in length, tracked the two ships into Winter Harbour, the crews "hailing the event with three loud and hearty cheers." The following year, when released from their icy prison, every effort was again made to pass the western extremity of Melville Island, but in vain; and, after many fruitless attempts, the ships returned to the eastward, and reached England in safety, bringing back every man who had embarked on the expedition, with the exception of one, who carried out with him an incurable complaint.

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The farthest point reached by Lieutenant, now Captain, Parry in the Polar Sea, was latitude 74° 26′ 25″ N. and longitude 113° 46′ 43″ W.; a point of western longitude which, by an amended act of Parliament, dividing the sum of L. 20,000 into a graduated scale, entitled the discoverers to L. 5000.

Of Parry and Lyon.

On their return to England, there was not an officer or man in the whole expedition that was not satisfied with the practicability of a western passage from the Atlantic to the Pacific; though in some other line of direction, either to the northward or the southward of the extensive group of islands among which they had been navigating. The Lords of the Admiralty appear to have entertained the same feelings, and accordingly gave directions for two bombs, the Fury and the Hecla, to be prepared for the prosecution of the discovery. To Captain Parry was given, as was justly due, the command of the expedition, and to Captain Lyon that of the Hecla. They left England in May 1821, and were last heard of high up in Hudson's Strait, in open water, and with a fair wind, on the 22d July, standing for the north-eastern extremity of the coast of America; the intention being to keep close along the northern coast of America, where, from experience, it is concluded a stream of water will be found between the land and the main body of the ice.

Probability of a Passage, from the information obtained.

The sketch here given of the various attempts which have been made for the discovery of a North-West, a North-East, and a Polar passage, is purely *historical*. The results have been uniformly unsuccessful; but though they have failed in the main object, it must not be concluded that they have been useless. On the contrary, they have been the means of accumulating a stock of information of the highest importance in almost every department of science, so as to entitle those who, at the expence of every personal comfort, embarked in them, to the gratitude of mankind. From the present state of our knowledge, thus acquired, a very probable conjecture may now be formed of the practicability, or otherwise, of a navigation through some part of the Polar Sea.

In the first place, it has been distinctly ascertained that human beings can winter with impunity to their health in the highest possible degree of cold which can exist in any part of the earth's surface; for there is every reason, short of actual proof, to believe, that the temperature of the atmosphere on the Pole itself is not lower (perhaps not so low) than in the parallel of 75°, where Parry wintered; the spirit in the thermometer having there descended to 55° below zero. So little, indeed, is a high parallel of latitude the sole cause of a decreased temperature, that, in 65° N., ten degrees less than Parry's winter-quarters, Lieutenant Franklin had the spirit in the tube down to 57°, two degrees lower than Parry. This officer, therefore, left England with the impression that he should experience no injury, nor much inconvenience, from passing a second winter in the Polar Sea, if it should be found necessary.

In the second place, it has now been ascertained in what situations it would be a waste of time to look for a passage, and where the only remaining points are deserving of examination. That a communication, if not a practicable passage, does exist between the Atlantic and the Pacific Oceans, through the medium of the Polar Sea, very little doubt can remain. The three known points of Icy Cape, Mackenzie's River, and Hearne River, go far to prove it; and the distance to which Parry proceeded to the westward, considerably beyond Hearne River, strengthens not a little this position.

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Another ground for concluding that a communication exists between the two oceans is, the constant current which the old navigators, Button, Fox, Middleton, and others, observed to set down the Welcome, and which also, in a less degree, prevails in Baffin's Bay and Davis' Strait; together with the current which as constantly sets up Behring's Strait, as appears from the journals of Cook, Clerke, Glottof, and Kotzebue. The fact of this circumvolving current, which we have no doubt contributes to those permanent movements everywhere existing in the great oceans, has been called in question, because Captain Ross found it running as much one way as the other in Baffin's Bay. Captain Ross had no further knowledge of currents than of those which agitate the surface of the sea, and which are known to change with every wind. Superficial currents, however, are not here meant, but the uniform motion of that great body of water, which, in spite both of winds and superficial currents, and in the teeth of both, carry icebergs many hundred feet immersed below the surface, and bear them along the coast of America, in direct opposition to the strongest and most extensive current that we know of, the Gulf Stream. How happens it, then, it may be asked, why none of these icebergs, so very commonly met with in the Atlantic, ever come across to the coast of Norway, or Denmark, Scotland, or Ireland, with the spray of the said currents, after reaching the banks of Newfoundland, and which brings with it so many other matters floating on the surface to these coasts? Or why do all the bottles which have been launched in Davis' Strait separate from the icebergs, and turn up on some of the above-mentioned coasts? Clearly, because there is a body of water acting on those parts of the icebergs under the surface (and which are at least thirty times the magnitude of the parts above the surface) in a contrary direction to that which is in motion above. This is so obvious as not to require another word on the subject. It is the icebergs only that are subject to this law: the field-ice, which is influenced and drifted about according to the winds and the currents on the surface, gives no indication of the direction in which the great body of water is moved.

In the same manner, we may be satisfied of the constant rush of water from the Pacific through Behring's Strait into the Polar Sea, to supply the constant stream which flows down the Welcome into Hudson's Bay. It is this current which, according to the observations of Kotzebue and the naturalist Chamisso, brings the great quantity of drift-wood into Behring's Strait and Kotzebue's Inlet. It is the same current by which, on the same authority, we are told, that the icebergs and fields of ice, which are formed and break up in the sea of Kamt-

schatka, "do not drift, as in the Atlantic, to the south, but into the Strait to the north;" and the strength of this set of the sea is stated to be from two and a half to three miles an hour, and that even in the teeth of a strong northerly wind. The conclusion drawn by M. Kotzebue is this, "that the constant north-east direction of the current of Behring's Strait proves that the water meets with no opposition, and, consequently, that a passage must exist, though perhaps not adapted to navigation. Observations have long been made that the current in Baffin's Bay runs to the south; and thus no doubt can remain that the mass of water which flows into Behring's Strait takes its course round America, and returns through Baffin's Bay into the ocean. But we have still more direct and positive information. Two Russian ships doubled the Icy Cape in 1821, and proceeded some forty or fifty miles beyond the point reached by Captain Cook; and such was the strength of the current *to the eastward*, that it was with the utmost difficulty they could stem it on their return, which a want of provisions, and of every requisite to pass the winter or encounter ice, compelled them to do; but they had no doubt whatever of a practicable passage.

An idea has heedlessly been started, that the superficial current in Baffin's Bay, and those which descend along the coast of Labrador, may be owing to the melting of the ice in summer; but if so, why does not the summer current at least descend through Behring's Strait instead of perpetually ascending it? But the supposition is altogether without foundation; for the quantity of ice destroyed *above* the surface will be replaced by very nearly the same quantity rising from *below* the surface; and, therefore, the water produced by the melting of the ice will merely supply the place of the latter, and not raise the surface of the sea above its usual level, nor produce any current. Be it observed too, that, in the Arctic Regions, little or no increase of the ice is occasioned by the fall of rain or snow.

Another objection, equally frivolous, was made against a communication of the waters of Hudson's Bay and Behring's Strait, on the ground, that the continent of Asia overlapped and was united to America, making Behring's Strait to terminate in a great bay. *That* question, however, has been set at rest for ever, even with those who were disposed to doubt of the voyage of Deschreff. The Russian government has recently employed several men of science to determine points of doubtful position on the northern coast of Siberia. In February 1821, Baron Wrangel, a distinguished officer in their service, left his head-quarters on the Nishey Kolyma to determine, by astronomical observation, the position of Shelatskoi-noss, or the North-east Cape of Asia, which was found to be in latitude 70° 05′ N., considerably lower than it is usually placed on the maps. He then proceeded over the ice directly north for 80 miles, without perceiving any other object than a boundless field of ice. The supposed continuation, therefore, of Asia to the eastward, may be considered an idle speculation.

Probable Direction of the Passage.

These facts being established, it may be assumed that a communication does exist between the two oceans; and, from the low latitude of the three known points of the coast of America, it may be inferred that this communication is a navigable one. The question then is narrowed to the direction in which it is most probable a passage will be found? The north-eastern route may be given up, were it only for the great distance (just one half of the whole circumference of the Polar Sea) that it would be necessary to navigate, more or less, among ice. The north-western, by keeping close along the coast of America, is now (1822) under trial; it is that which Captain Parry has judged to be the most feasible from the experience he had acquired along the western coast of Old Greenland, the shores of the western islands of Baffin's Bay, and the southern shores of the numerous islands between the entrance of Barrow's Strait and the western extremity of Melville Island; in all of which places a navigable channel of water was found between the land and the ice. The same thing invariably happens along the western shore of Spitzbergen, and probably along the eastern coast of Old Greenland, when once fairly in with the land. It was proved, indeed, at Winter Harbour, with what extraordinary rapidity the radiated heat of the land melted the ice on the return of summer; and as the coast of America is five degrees of latitude more southerly than Melville Island, the former has a full month more of summer than the latter. The only circumstance which militates against an uninterrupted open channel along that coast, is that of its being a lee-shore to the northerly winds, which appear to be the most prevailing in the Arctic Seas; though Parry found them drawing generally either to the eastward or westward in the direction of the strait. It is not quite certain, however, though every appearance is favourable, that the north-eastern extremity of America terminates at the head of the Welcome, in or about what is called on the charts Repulse Bay; but there is no doubt, that the Regent's Inlet on the south side of Barrow's Strait leads down upon that coast.

The tract pursued on the late voyage through Barrow's Strait, and among the islands, must obviously be given up as hopeless. The north-westerly winds had wedged in such a mass of ice among the islands which never melts, as to render all attempts to penetrate it at the western opening of the funnel impracticable; but beyond this ice, Captain Parry had no doubt there was an open sea; as it was observed whenever the wind came to the eastward, that the whole body of the ice kept moving to the westward for several days together. And this open sea is probably not inaccessible from some other quarter. There is an opening on the northern side of Barrow's Strait in the meridian of 92°, which Captain Parry has named Wellington's Channel. This "grand opening," as Parry calls it, was free from every particle of ice, as far as the eye could reach on a fine clear day, and apparently as open and navigable as any part of the Atlantic. This channel, therefore, in all probability, leads to an open sea to the northward of the archipelago of islands, which, there is every reason to believe, is

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connected with Baffin's Bay by the great inlets known by the names of Smith's Sound and Alderman Jones's Sound.

Probability of a great portion of the Polar Sea being free from Ice.

The most important part of the question is, whether the great body of the Polar Sea is composed of water or land. The absence of icebergs in the long tract from Baffin's Bay to Melville Island, and in the seas around Spitzbergen, affords at least a strong presumption against the existence of high precipitous land rising out of a deep ocean, without which, no formation of these huge masses of ice, some of which are not far short of a thousand feet in height, can possibly take place. If, then, the Polar Sea should be free from land, it will, in all probability, be also sufficiently free of ice for the purposes of navigation; for, although it is not doubted that the deep and wide sea will freeze over, yet it is well known that, by the navigation of the water in these boisterous latitudes, the ice formed on the surface is soon broken up, heaped together, and drifted with the wind to some shore or islands, where it becomes fixed, or floated so far down to the southward as to undergo a dissolution. If this was not the case, and we were to suppose the whole surface of the Polar Sea to be once frozen over into one dense and compact mass of ice, that mass must continue to increase from year to year, till that part of the ocean become one solid and immoveable body. On the whole, then, we should say, that the probability of an open sea towards the North Pole rather predominates; it is a theory which has been entertained since the days of Dr Hooke; and all the Greenland fishermen are impressed with this opinion.

Probable Mean Temperature of the Pole.

Dr Brewster, in an ingenious and interesting paper on "the Mean Temperature of the Globe," has shown, in a satisfactory manner, by comparing the results of the late expedition with those he had drawn from a preconceived theory, "that the mean temperature of the North Pole of the globe will be about 11°," which, he says, is "incomparably warmer than the regions in which Captain Parry spent the winter." The mean annual temperature of this spot, according to a series of accurate observations for twelve months, was actually 1°, 33′; and on shore could not have been more than 1° below zero.

Shortest Route to Behring's Strait.

But if the Polar Sea should be tolerably free from ice and islands, and it were possible to pass the barrier of ice which is usually jammed in between Spitzbergen and Old Greenland, and no doubt it is possible, in many years, as may also be the case on the eastern side of Spitzbergen in most years, the route by this way, and close to the Pole, being on a great circle, would be by far the shortest in point of distance, cutting off not less than the whole width of the Atlantic from the Shetland Islands to Cape Farewell. The accident that happened to Captain Buchan's ship is greatly to be regretted, as otherwise there was every prospect of much new information being obtained in this quarter, which is not likely to be acquired from private ships; for although the present graduated scale of rewards, which commence at the latitude 83°, would appear to encourage masters of fishing ships to avail themselves of favourable openings, which frequently occur, to run for that latitude, we have little hope of a whale-fishing ship attempting it, and thereby perhaps running the risk of losing the short and precarious opportunity of accomplishing the main object of the voyage.

Polar Seas.

Coast of the Polar Sea Inhabited.

The whole surrounding coast of the North Polar Sea is inhabited; the European part with Laplanders and Finns; the Asiatic shores with Ostiacks, Samoyedes, Yuckagires, Tchutskies, and Koriacks, who derive their subsistence from the rein-deer and dried fish. The Tchutskoi bordering on Behring Strait are a superior kind of Eskimaux, and are no doubt the same race which extend along the northern coast of America, the shores and islands of Baffin's Bay, Davis and Hudson's Straits, and the coast of Labrador; and as high up on the coast of Old Greenland as latitude 78°, the highest habitable spot, in all probability, on the globe. All these people, distantly as they are removed from each other, speak the same language, wear the same dress, subsist in the same manner, and in all their habits and appearance are precisely the same people. Spitzbergen has no permanent inhabitants, but English, Dutch, Danes, and Russians, have frequently wintered there; and even as high as 80° N. many hundreds, some say thousands, of graves, are met with in two or three particular spots where it was usual to extract the oil from the whale and other marine animals furnishing blubber. On Nova Zembla, the body of which is five or six degrees lower in latitude, no inhabitants are found, nor, with the exception of Barentz and his associates, have any been known to pass the winter even in the more southerly parts. Such, indeed, is the difference of climate on the same parallels, that while on the southern part of Nova Zembla, in latitude 69°, not a shrub is to be found, at Altengoord, in Norway, in latitude 70°, trees grow to a considerable size. Old Greenland, and the islands on the western shore of Baffin's Bay, of Davis Strait, and of Hudson's Bay, down to the 55th degree of latitude, are barren of trees and shrubs; while, on the western side of America, as high up as the 60th and even 65th degree, the firs and birch grow to a considerable size. Even in the short distance which separates America from Asia across Behring's Strait, Kotzebue, in passing from the former to the latter, experienced a change like that of summer and winter; in the former all was verdure, in the latter, a complete surface of ice and snow. On the south side of Melville Island, in 75° of latitude, the moment that the snow had departed, the ground was enamelled with a variety of brilliant flowers.

Animals of the Northern Regions.

Nor are these dreary regions entirely destitute of animated nature. Rein-deer are met with on the northernmost part of Spitzbergen. The polar bear, the wolf, the arctic fox, the polar hare, the ermine, the lemming or Hudson's Bay mouse, the musk-bull, and the rein-deer, were all caught on Melville Island, the first six being perpetual residents, the two last migratory. Grouse, ptarmigan, plover, and a great variety of water-fowl, frequent in vast numbers the straits and islands of the arctic seas. The following picture, drawn by the naturalist who accompanied Kotzebue, is correct and interesting: "As, on the one hand, in proportion as you advance farther on the land towards the north, the woods become less

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POLAR REGIONS

Engd by W.H. Lizars

Published by A. Constable & Co. Edinr. 1822.

POLAR REGIONS

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Polar Seas.

lofty, the vegetation gradually decreases, animals become scarcer, and lastly (as on Nova Zembla), the rein-deer and the *glires* vanish with the last plants, and only birds of prey prowl about the icy streams for their food: so, on the other hand, the sea becomes more and more peopled. The *algæ*, gigantic species of *tang*, form inundated woods round the rocky coasts, such as are not met with in the torrid zone. But the waters swarm with animal life—the *medusæ* and *zoophytes*, *molluscæ* and *crustaceæ*, innumerable species of fish, in incredibly crowded shoals; the gigantic swimming *mammalia*, whales, physeters, dolphins, morse, and seals, fill the sea and its shores, and countless flights of water-fowl rock themselves on the bosom of the ocean, and in the twilight resemble floating islands."

South Polar Sea.

Confined Knowledge of the South Polar Sea.

Of the South Polar Sea little or nothing may be said to be known. Captain Cook, in the years 1773 and 1774, crossed the Antarctic Circle in *five* places only;—in longitude 39½° E., where he advanced to latitude 67½°, and met with fields and detached pieces of ice; in longitudes 101° and 110° W., between which he proceeded to latitude 71° 10′ S., the farthest progress made by him towards the South Pole, where he was stopped, or at least deemed it prudent to return, on account of the fields and mountains of ice which were scattered over the surface of the sea; and in longitude 136° and 148° W., between which he descended to latitude 68°, and saw many floating ice islands. There are, therefore, still remaining about 340 degrees of longitude in which the Antarctic circle has not been crossed, and full half the circumference of the globe which has not been visited lower to the southward than the parallel of 60° south latitude.

There can be little doubt of the existence of high land in the South Polar Sea, though Cook discovered none beyond the Southern Thule or Sandwich Land, on the parallel of 60°. Without high precipitous land, those large icebergs which he met with floating among the fields of ice could not have been formed; the *hummocks* of ice, occasioned by the agitation of the sea and the meeting of the *fields* or *flaws* in opposite directions, seldom rise to the height of twelve or fifteen feet above the surface. The Russians, indeed, on a recent voyage of discovery, are said to have fallen in with many islands about the 70th parallel of latitude; they also circumnavigated the Sandwich Land, which was left undetermined by Cook, and conjectured that it might be a part of the great Southern Continent, which occupied so much of the attention of geographers and philosophers of the last century. This idea was renewed by the recent discovery of a very considerable extent of land to the southward of Cape Horn, in latitude 63°, and seen extending from longitude 55° to 65° W. As the eastern extremity had not been seen, and the winding of the coast was to the N. E., it was conjectured that it might unite with the Southern Thule of Cook, and form the long sought for Southern Continent. It is said, however, that the Russians have also circumnavigated this land, and that it is composed of a great cluster of islands.

Polar Seas.

South Shetland.

The land in question has been called South Shetland, but it is no new discovery. In the account of the voyage of *The Five Ships of Rotterdam*, under the command of Jacob Mahu and Simon de Cordes, to the South Seas, in the year 1599, it is stated, that, on approaching the Strait of Magelhaens, the yacht, commanded by Dirk Gherritz, was separated from all the other ships, and was carried by tempestuous weather to the south of the strait to 64° S. latitude, where they discovered a high country, with mountains which were covered with snow, like the land of Norway. This land of Gherritz was marked on some of the old charts, but discontinued on the more modern ones, from the uncertainty of its position with regard to longitude. There can be no doubt of its identity with the modern South Shetland. It answered to the description of the mountains of Norway, covered with snow, and is wholly barren, having neither tree nor shrub of any kind. It is unnecessary to say, that it is uninhabited, there being no such people in the southern hemisphere as the Eskimaux; and it may be remarked, that no human beings are found in the Southern Ocean below the 55th parallel of latitude, and none beyond the 50th, except on Patagonia and Terra del Fuego. On the shores, the seals and sea-horses, which had remained from the creation undisturbed, were so numerous, that on the first notice of the rediscovery, a whole fleet of vessels from England and North America crowded thither on speculation; but the loss of several, from tempestuous weather and a dangerous navigation, and the destruction and alarm of the objects of their cupidity, will probably cause it, for some time at least, to remain as much a land of desolation as it had been before.

Since the preceding article was written, the return of Captain Franklin has completely settled the geography of the mouth of the Copper Mine River, and between 500 and 600 miles to the eastward of it. The latitude of this river, which Hearne originally stated to be upwards of 72° N., but which was afterwards reduced to 69°, is now determined to be 67° 48′ N., and longitude 115° 30′ W., which is five degrees more westerly than is usually laid down on the charts. One part of the coast, to the eastward of Hearne's River, was found to come down as low as the Arctic Circle, or 66° 30′ N. Little or no ice was floating on the sea, which was deep and unobstructed, on which ships of any burden might freely navigate; and thus the theory, upon the strength of which Captain Parry is at present proceeding, is confirmed; and Captain Franklin has every reason to believe, that when once he gets upon the coast of North America, he will find no difficulty in making good his passage. Captain Franklin also found that the general current set to the eastward, as all the driftwood was found on the *western* sides of the jutting promontories. Nearly parallel to the coast, and at the distance of five or six miles from it, a range of numerous islands extended the whole length of the passage made by Captain Franklin.

(K.)

POLITICAL ECONOMY.

Political Economy.

The greater number of the subordinate parts of the science of Political Economy have been treated, in various articles of this *Supplement*, with the fulness which their relative importance seemed to require. In the present article, therefore, we shall principally confine ourselves to an attempt to define the objects and limits of the science—to trace its progress—to exhibit and establish the fundamental principles on which it is founded—and to point out the relation and dependence subsisting between its different parts. In doing this, we shall have occasion to examine the more prominent of the theories which have been advanced in this field of inquiry; our object being, not merely to lay before our readers what we conceive to be a true theory of the science, but also to present them with as full an exposition as our limits will allow of the particular doctrines advocated by the most celebrated of its professors.

Part I.—Definition and History.

Definition of the Science—Causes of its being neglected in Greece and Rome, and in the Middle Ages—Species of Evidence on which its Conclusions are founded—Rise of the Science in Modern Europe—Mercantile System—Progress of Commercial Philosophy in England in the Seventeenth and Eighteenth Centuries—System of M. Quesnay and the French Economists—Publication of the "Wealth of Nations"—Distinction between Politics and Statistics and Political Economy.

Definition of the Science.

Political Economy* is *the science of the laws which regulate the production, distribution, and consumption of those material products which have exchangeable value, and which are either necessary, useful, or agreeable to man.*

This definition has been framed so as to exclude all reference to such articles as exist independently of man, and of which unlimited quantities can be obtained without any degree of laborious exertion. Had such been the case with all the articles required to satisfy our wants, and to gratify our desires, this science would either have had no existence at all, or would have been cultivated only as a source of amusement, without any view to utility. Political Economy is exclusively conversant with objects which come within the observation of every man, and which are continually modified by human interference. It is, in fact, the *science of values;* and nothing which is not possessed of exchangeable value, or which will not be accepted as an equivalent for something else, can come within the scope of its inquiries. It is obvious, however, that an article may be possessed of the highest degree of *utility*, or, as it is sometimes termed, of intrinsic worth, and yet be wholly destitute of exchangeable value. Without utility of some species or another, no article will ever be an object of demand; but how necessary soever any particular article may be to our comfort, or even existence, and however great the demand for it, still, if it be a spontaneous production of nature—if it exists independently of human agency, and if every individual has an indefinite command over it, it can never become the subject of an exchange, or afford a basis for the reasonings of the economist. It cannot justly be said, that the food with which we appease the cravings of hunger, or the clothes by which we defend ourselves from the inclemency of the weather, are more useful than atmospheric air; and yet they are possessed of that exchangeable value of which it is totally destitute. The reason is, that food and clothes are not, like air, gratuitous products: they cannot be had at all times, and without any exertion; they are *obtainable only by labour;* and as no one will voluntarily sacrifice the fruits of his industry, without receiving an equivalent in return, they are truly said to possess exchangeable value.

Definition.

Distinction between Value in Exchange and Utility.

The word *value* has, we are aware, been very generally employed to express, not only the exchangeable worth of a commodity, or its capacity of exchanging for other commodities, but also to express its *utility*, or its capacity of satisfying our wants, and of contributing to our comforts and enjoyments. But it is obvious, that the utility of commodities—that the capacity of bread, for example, to appease hunger, or of water to quench thirst—is a totally different and distinct quality from their capacity of exchanging for other commodities. Dr Smith perceived this difference, and showed the importance of carefully distinguishing between the utility, or, as he expressed it, the "value in use," of commodities, and their value in exchange. But he did not always keep this distinction in view, and it has been very generally lost sight of by M. Say, Mr Malthus, and other late writers. We have no doubt, indeed, that the confounding together of these opposite qualities has been one of the principal causes of the confusion and obscurity in which many branches of the science, not in themselves difficult, are still involved. When, for example, we say that water is highly valuable, we unquestionably attach a very different meaning to the phrase from what we attach to it when we say that gold is valuable. Water is indispensable to existence, and has, therefore, a high degree of utility, or of "value in use;" but as it can be generally ob-

* *Economy*, from οἶκος, a house, or family, and νομὸς, a law—*the government of a family.* Hence Political Economy may be said to be to the state what domestic economy is to a single family.

Definition.

tained in large quantities, without much labour or exertion, it has, in most places, but a very low value in exchange. Gold, on the other hand, is of comparatively little utility; but as it exists only in limited quantities, and as a great deal of labour is necessary to procure a small supply of it, it has a high exchangeable value, and may be exchanged or bartered for a large quantity of most other commodities. To confound these different sorts of value would evidently lead to the most erroneous conclusions. And hence, to avoid all chance of error from mistaking the sense of so important a word as *value*, we shall never use it except to signify exchangeable worth, or value in exchange; and shall always use the word *utility* to express the power or capacity of an article to satisfy our wants, or gratify our desires.

A few words will suffice to show the necessity and importance of always distinguishing between the utility of a commodity and its value. If utility and value in exchange were identical, or if they were regulated by the same laws, it would necessarily follow, that the same circumstances which were calculated to increase the utility of any article would also increase its value, and *vice versa*. But the fact is distinctly and completely the reverse. The utility of a commodity is never increased by simply raising, but it is, in the great majority of instances, increased by lowering, its value. A deficient harvest increases the exchangeable value of corn, but most certainly it does not increase its utility. If such an improvement were to take place in the manufacture of hats as would enable them to be produced for a half of the expence it now takes to bring them to market, their value, and consequently their price, would very soon be reduced a half also. Each individual would thus be able to buy two hats for the same sum it had formerly required to buy one; and while the *utility* of no single hat would be impaired by this fall of value, it is plain that the sphere of their utility would be greatly extended, and that they would be brought within the reach of a large proportion of those whose poverty might previously have rendered them unable to obtain them. In fact, the grand object of the science of Political Economy is to discover the means by which the value of commodities may be reduced to the lowest possible limits. For, the more their value is reduced, the more obtainable they become, and the greater, consequently, is the amount of the necessaries, conveniences, and luxuries at the disposal of every individual.

Definition of the term *Wealth*.

Political Economy has been frequently defined to be "the science which treats of the production, distribution, and consumption of *wealth*;" and if by wealth be meant those material products which possess exchangeable value, and which are necessary, useful, or agreeable to man, the definition is quite unexceptionable. But the economists who have adopted this definition have attached a different, and a much too extensive meaning to the term wealth. They have sometimes, for example, considered wealth as synonymous with "*all that man desires as useful and agreeable to him.*" But if Political Economy were to embrace a discussion of the production and distribution of all that is useful and agreeable, it would include within itself every other science; and the best Encyclopædia would really be the best treatise on Political Economy. Good health is useful and delightful, and, therefore, on this hypothesis, the science of wealth ought to comprehend the science of medicine; civil and religious liberty are highly useful, and, therefore, the science of wealth must comprehend the science of politics; good acting is agreeable, and, therefore, to be complete, the science of wealth must embrace a discussion of the principles of the histrionic art, and so on. Such definitions are obviously worse than useless. They can have no effect but to generate confused and perplexed notions respecting the objects and limits of the science, and to prevent the student ever acquiring a clear and distinct idea of the nature of the inquiries in which he is engaged.

Mr Malthus has defined wealth to consist of "those material objects which are necessary, useful, and agreeable to man." (*Principles of Political Economy*, p. 28.) But this definition, though infinitely less objectionable than the preceding, is much too comprehensive to be used in Political Economy. Atmospheric air, and the heat of the sun, are both material products, and are highly useful and agreeable. But their independent existence, and their incapacity of appropriation, excludes them, as we have already shown, from the investigations of this science.

Dr Smith has not explicitly stated what was the precise meaning attached by him to the term wealth; but he most commonly describes it to be "the annual produce of land and labour." Mr Malthus, however, has justly objected to this definition, that it refers to the sources of wealth, before we know what wealth is, and that it includes all the useless products of the earth, as well as those which are appropriated and enjoyed by man.

The definition we have given is not liable to any of these objections. By confining the science to a discussion of the laws regulating "the production, distribution, and consumption of those material products which have exchangeable value, and which are either necessary, useful, or agreeable," we give to it a distinct and definite object. When thus properly restricted, the researches of the economist occupy a field which is exclusively his own. He runs no risk of wasting his time in inquiries which belong to other sciences, or in unprofitable investigations respecting the production and consumption of articles which cannot be appropriated, and which exist independently of human industry.

Capacity of appropriation is indispensably necessary to constitute wealth. And we shall invariably employ this term to distinguish those products only which are obtained by the intervention of human labour, and which, consequently, can be appropriated by one individual, and consumed exclusively by him. A man is not said to be wealthy, because he has an indefinite command over atmospheric air, for this is a privilege which he enjoys in common with every other man, and which can form no ground of distinction; but he is said to be wealthy, according to the degree in which he can afford to command those neces-

Definition.

saries, conveniences, and luxuries which are not the gifts of nature, but the products of human industry. It must, however, be carefully observed, that, although the possession of value be thus necessary to the existence of wealth, they cannot be confounded together without leading to the most erroneous conclusions. Wealth and value are as widely different as utility and value. It is plain that every man will be able to command a much greater quantity of these necessaries and gratifications, of which wealth consists when their value declines, or when they become more easily obtainable, than when their value increases. *Wealth and value vary in an inverse ratio.* The one increases as the other diminishes, and diminishes as the other increases.—Wealth is greatest where the facility of production is greatest, and value is greatest where the difficulty of production is greatest.

Importance of the Science.

The science of Political Economy is exclusively conversant with that class of phenomena, which the exertion of human industry exhibits. Its object is to ascertain the means by which this industry may be rendered most productive of necessaries, comforts, luxuries, and enjoyments, or of wealth in the proper sense of the word; by which this wealth may be most advantageously distributed among the different classes of the society; and by which it may be most profitably consumed. To enter into a lengthened argument to prove the importance of a science having such objects in view, would be worse than useless. The consumption of wealth is indispensable to existence; but the eternal law of Providence has decreed that wealth can only be procured by the intervention of industry —that man must earn his bread by the sweat of his brow. This twofold necessity renders the production of wealth a constant and principal object of the exertions of the vast majority of the human race. It has subdued the natural aversion of man to labour, given activity to indolence, and armed the patient hand of industry with zeal to undertake, and perseverance to overcome, the most difficult and disagreeable tasks. But when wealth is thus necessary, when the desire to acquire it is sufficient to induce us to submit to the greatest privations, it is plainly impossible to doubt the utility and paramount importance of the science which teaches the modes by which its acquisition may be facilitated, and by which we may be enabled to obtain the greatest amount of wealth with the least possible difficulty. There is no class of people to whom a knowledge of this science can be considered as either extrinsic or superfluous. There are some, doubtless, to whom it may be of more advantage than to others; but it is of the utmost consequence to all. The prosperity of individuals, and consequently of nations, does not depend nearly so much on salubrity of climate, or on the fertility and convenient situation of the soils they inhabit, as on the power possessed by them, of applying their labour with perseverance, skill, and judgment. Industry can balance almost every other deficiency. It can render regions naturally inhospitable barren and unproductive, the comfortable abodes of an intelligent and refined, a crowded and wealthy population; but where it is wanting, the most precious gifts of nature are of no value, and countries possessed of the greatest capabilities of improvement, with difficulty furnish a miserable subsistence to the scanty population of hordes distinguished only by their ignorance, barbarism, and wretchedness.

Objects and Importance of the Science.

Causes of the Neglect of this Science in the Ancient and Middle Ages.

But when the possession of wealth is thus necessary to individual existence and comfort, and to the advancement of nations in the career of civilization, it may justly excite our astonishment that so few efforts should have been made to discover its sources, and facilitate its acquisition, and that the study of Political Economy, should not have been early considered as forming a principal part in a comprehensive system of education. Two circumstances, to which we shall now briefly advert, seem to us to have been the principal causes of the neglect of this science. The first is the institution of *domestic slavery* in the ancient world; and the second the darkness of the period when the plan of education in the universities of modern Europe was first organized.

The citizens of Greece and Rome considered it degrading to employ themselves in those occupations which form the principal business of the inhabitants of modern Europe. In some of the Grecian states the citizens were prohibited from engaging in any species of manufacturing or commercial industry; and in Athens and Rome, where such a prohibition did not exist, these employments were universally regarded as mean, mercenary, and unworthy of freemen, and were in consequence carried on exclusively by slaves, or the very dregs of the people. *

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* The force of the prejudices on this head may be learned from the following quotations: "Illiberales autem et sordidi," Cicero says, "questus mercenariorum, omniumque quorum operæ, non quorum artes emuntur. Est enim illis ipsa merces auctoramentum servitutis. Sordidi etiam putandi, qui mercantur a mercatoribus quod statim vendant, *nihil enim proficiunt, nisi admodum mentiantur!* Opificesque omnes in sordida arte versantur, *nec enim quidquam ingenuum potest habere officina* * * * Mercatura autem, si tenuis est, sordida putanda est; sin autem magna et copiosa, multa undique apportans, multisque sine vanitate impertiens, non est admodum vituperanda" (*De Officiis*, Lib. I. sect. 42.)

"Vulgaris opificum, quæ manu constant, et ad instruendam vitam occupatæ sunt; in quibus nulla decoris, nulla honesti simulatio est." (*Senecæ Epistolæ*, Ep. 89.)

A hundred similar quotations might be produced; but the one we have given from Cicero is sufficient to establish the accuracy of what we have advanced. The strength of the prejudice against commerce and the arts is proved by its exerting so powerful an influence over so cultivated a mind. For a further discussion

Causes of the neglect of Political Economy.

Agriculture was treated with more respect. Some of the most distinguished characters in the earlier ages of Roman history had been actively engaged in rural affairs; but, notwithstanding their example, in the flourishing period of the Republic, and under the Imperial *Regime*, the cultivation of the soil was almost entirely carried on by slaves, belonging to the landlord, and employed on his account. The mass of Roman citizens were either engaged in the military service, * or derived a precarious and dependant subsistence from the supplies of corn furnished by the conquered provinces. In such a state of society the relations subsisting in modern Europe between landlords and tenants, and masters and servants, were unknown; and the ancients were in consequence entire strangers to all those interesting and important questions arising out of the rise and fall of rents and wages, which form so important a branch of economical science. The spirit of the philosophy of the ancient world was also extremely unfavourable to the cultivation of Political Economy. The luxurious or more refined mode of living of the rich, was regarded by the ancient moralists as an evil of the first magnitude. They considered it as subversive of those warlike virtues, which were the principal objects of their admiration, and, in consequence, they denounced the passion for accumulating wealth as fraught with the most injurious and destructive consequences. It was impossible that Political Economy could become an object of attention, to men imbued with such prejudices; or that it could be studied by those who held the objects about which it is conversant in contempt, and who spurned that labour by which wealth is produced.

At the establishment of our universities, the clergy were almost the exclusive possessors of the little knowledge then in existence. It was natural, therefore, that their peculiar feelings and pursuits should have a marked influence on the plans of education they were employed to frame. Grammar, rhetoric, logic, school divinity, and civil law, comprised the whole course of study. To have appointed professors to explain the principles of commerce, and the means by which labour might be rendered most effective, would have been considered as equally superfluous and degrading to the dignity of science. The prejudices against commerce, manufactures, and luxury, generated in antiquity, had a powerful influence in the middle ages. None were possessed of any clear ideas concerning the true sources of wealth, happiness, and prosperity. The intercourse between the different countries was extremely limited, and was rather confined to marauding excursions, and a piratical scramble for the precious metals, than to a commerce founded on the gratification of real or reciprocal wants.

These circumstances sufficiently account for the slow progress of, and the little attention paid to this science up to a very recent period. And since it became an object of more general attention and liberal inquiry, the opposition between the theories and opinions that have been espoused by the most eminent of it professors,—a necessary and inevitable result, as we shall immediately show, of its recent cultivation, has proved exceedingly unfavourable to its progress, and has generated a disposition to distrust its best established conclusions. This prejudice is, however, extremely ill-founded; and notwithstanding the diversity of the theories that have been formed to explain its various phenomena, Political Economy admits of as much certainty in its conclusions as any science not exclusively dependent on mere relation. A brief exposition of the nature of the principles on which it is founded, and of the mode in which its investigations ought to be conducted, will evince the correctness of this statement.

Principles of the Science. Nature of the Evidence on which its Conclusions are Founded.

Political Economy is not a science of speculation, but of fact and experiment. The principles on which the production and accumulation of wealth and the progress of civilization depend, are not the offspring of legislative enactments. Man must exert himself to produce wealth, because he cannot exist without it; and the desire implanted in the breast of every individual of rising in the world and improving his condition, impels him to save and accumulate. The principles which form the basis of this science make, therefore, a part of the original constitution of man and of the physical world, and their operations, like those of the mechanical principles, are to be traced by the aid of observation and analysis. There is, however, a material distinction between the physical and the moral and political sciences. The conclusions of the former apply in *every* case, while those of the latter only apply in the *majority* of cases. The principles on which the production and accumulation of wealth depend are inherent in our nature, but they do not exercise precisely the same influence over the conduct of every individual; and the theorist must satisfy himself with framing his general rules so as to explain their operation in the majority of instances, leaving it to the sagacity of the observer to modify them so as to suit individual cases. Thus it is an admitted principle in the science of Morals, as well as of Political Economy, that by far the largest proportion of the human race have a much clearer view of what is conducive to their own interests, than it is possible for any other man, or select number of men to have, and consequently that it is sound policy to allow every individual to follow the bent of his inclination, and to engage in any branch of industry he thinks proper. This is the general theorem; and it is one which is established on the most comprehensive experience. It is not, however, like the laws which regulate the motions of

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of the opinions of the Romans on this subject, we refer our readers to the *Dissertazione del Commercio de Romani* of Mengotti, which received a prize from the Academy of Paris in 1787, and to the *Memoria Apologetica del Commercio de Romani* of Torres, published at Venice in 1788.

* "Rei militaris virtus præstat cæteris omnibus; hæc populo Romano, hæc huic urbi æternam gloriam peperit."—(Cicero pro *Murena*.)

Evidence on which the Conclusions of Political Economy are Founded.

the planetary system,—it will hold good in nineteen out of twenty instances, but the twentieth may be an exception. But it is not required of the economist, that his theories should quadrate with the peculiar bias of the mind of a particular person. His conclusions are drawn from contemplating the principles which are found to determine the condition of mankind, as presented on the large scale of nations and empires. His business is with man in the aggregate —with states, and not with families—with the passions and propensities which actuate the great bulk of the human race, and not with those which are occasionally found to influence the conduct of a solitary individual.

This distinction should be kept constantly in view. Nothing is more common than to hear it objected to some of the best established truths in political and economical science, that they are at variance with certain facts, and that, therefore, they must be rejected. But these objections very often originate in an entire misapprehension of the nature of the science. It would be easy to produce a thousand instances of individuals who have been enriched by monopolies and restrictions, and even by robbery and plunder; though it would certainly be a little too much to conclude from thence that society could be enriched by such means! This, however, is the single consideration to which the political economist has to attend;—and, until it can be shown that monopolies and restrictions are not destructive of *national wealth*, and that what is gained by the monopolist is not lost by the public, he is justified in considering them injurious. To arrive at a well-founded conclusion in economical science, it is not enough to observe results in particular cases, or as they affect particular individuals; we must further inquire whether these results are *constant* and *universally applicable*—whether the same circumstances which have given rise to them in one instance, would in every instance, and in every state of society, be productive of the same or similar results—A theory which is inconsistent with an *uniform* and *constant* fact, must be erroneous; but the observance of a particular result at variance with our customary experience, and when we may not have had the means of discriminating the circumstances attending it, ought not to induce us hastily to modify or reject a principle which accounts satisfactorily for the greater number of appearances.

The example of the few arbitrary princes who have been equitable, humane, and generous, is not enough to overthrow the principle which teaches that it is the nature of irresponsible power to debauch and vitiate its possessors—to render them haughty, cruel, and suspicious; nor is the example of those who, attentive only to present enjoyment, and careless of the future, lavish their fortunes in boisterous dissipation or vain expence, sufficient to invalidate the general conclusion, that the passion for accumulation is stronger and more powerful than the passion for expence. Had this not been the case, mankind could never have emerged from the condition of savages. The multiplied and stupendous improvements which have been made in different ages and nations—the forests that have been cut down—the marshes and lakes that have been drained and cultivated—the harbours, roads, and bridges that have been constructed—the cities and edifices that have been raised—are *all* the fruit of a saving of income, and establish, in despite of a thousand individual instances of prodigality, the ascendancy and superior force of the accumulating principle.

Evidence on which the Conclusions of Political Economy are Founded.

It is from the want of attention to these considerations that much of the error and misapprehension with which the science of Political Economy has been, and still is infected, has arisen. Almost all the absurd theories and opinions which have successively appeared have been supported by an appeal to facts. But a knowledge of facts, without a knowledge of their mutual relation—without being able to show why the one is a cause and the other an effect—is, to use the illustration of M. Say, really no better than the indigested erudition of an almanack maker, and can afford no means of judging of the truth or falsehood of a general principle.

But, although we are not to reject a received principle because of the apparent opposition of a few results, with the particular circumstances of which we are unacquainted, we can have no confidence in its solidity if it be not deduced from a very comprehensive and careful induction. To arrive at a true knowledge of the laws regulating the production, distribution, and consumption of wealth, the economist must draw his materials from a very wide surface; he should study man in every different situation—he should have recourse to the history of society, of arts, of commerce, and of civilization—to the works of philosophers and travellers—to every thing, in short, that can throw light on the causes which accelerate or retard the progress of civilization. He should observe the changes which have taken place in the fortunes and condition of the human race in different regions and ages of the world. He should trace the rise, progress, and decline of industry, and he should carefully discriminate the effect of different political measures, and the various circumstances wherein an advancing and declining society differ from each other. Such investigations, by disclosing the real causes of national opulence and refinement, and of poverty and degradation, furnish the economist with the means of giving a satisfactory solution of almost all the important problems in the science of wealth, and of devising a scheme of public administration calculated to ensure the continued advancement of the society in the career of improvement.

It must always be kept in mind that it is no part of the business of the economist to inquire into the means by which individual fortunes may have been increased or diminished, except to ascertain their general operation and effect. The *public interests* ought always to form the exclusive objects of his attention. He is not to frame systems, and devise schemes, for increasing the wealth and enjoyments of *particular classes;* but to apply himself to discover the sources of *national wealth*, and *universal prosperity*, and the means by which they may be rendered most productive.

Rise of the Science in Modern Europe.

When we reflect on the variety and extent of the previous knowledge requisite for the construction of a sound theory of Political Economy, we cease to feel any surprise at the errors into which economists have been betrayed, or at the discrepancy of the opinions which are still entertained on some important points. Political Economy is of very recent origin. Though various treatises of considerable merit had previously appeared on some of its separate parts, it was not treated as a whole, or in a scientific manner, until about the middle of last century. This circumstance is of itself enough to account for the number of erroneous systems that have since appeared. Instead of deducing their general conclusions from a comparison of particular facts, and a careful examination of the phenomena attending the operation of different principles, and of the same principles in different circumstances, the first cultivators of almost every branch of science have begun by framing their theories on a very narrow and insecure basis. Nor is it really in their power to go to work differently Observations are scarcely ever made or particulars noted for their own sakes. It is not until they begin to be in request as furnishing the only test by which to ascertain the truth or falsehood of some popular theory, that they are made in sufficient numbers, and with sufficient accuracy. It is, in the peculiar phraseology of this science, the *effectual demand* of the theorist that regulates the production of the facts or raw materials, which he is afterwards to work into a system. The history of Political Economy strikingly exemplifies the truth of this remark. Being, as we have already observed, entirely unknown to the ancients, and but little attended to by our ancestors up to a comparatively late period, those circumstances which would have enabled us to judge with the greatest precision of the wealth and civilization of the inhabitants of the most celebrated states of antiquity, and of Europe during the middle ages, have either been thought unworthy of the notice of the historian, or have been only very imperfectly and carelessly detailed. Those, therefore, who first began to trace the general principles of the science had but a comparatively limited and scanty experience on which to build their conclusions. Nor did they even avail themselves of the few historical facts with which they might have easily become acquainted, but almost exclusively confined their attention to those which happened to fall within the sphere of their own observation.

Mercantile System.

Agreeably to what we have now stated, we find that the theories advanced by the early economical writers were formed on the most contracted basis, and were only fitted to explain a few of the most obvious and striking phenomena. The *Mercantile Theory*, for example, was entirely bottomed on the popular and prevalent opinions respecting money. The precious metals having been long used, both as a standard whereby to ascertain the comparative value of different commodities, and as the equivalents for which they were most frequently exchanged, acquired a fictitious importance, not merely in the estimation of the vulgar, but in that of persons of the greatest discernment. The simple consideration that all buying and selling is really nothing more than the bartering of one commodity for another—of a certain quantity of corn or wool, for example, for a certain quantity of gold or silver, and *vice versa*, was entirely overlooked. The attention was gradually transferred from the *money's worth* to the money itself; and the wealth of individuals and of states came to be measured, not by the abundance of their disposable products—by the quantity or value of the commodities with which they could afford to purchase the precious metals—but by the *quantity of these metals* actually in their possession. It is on this flimsy and fallacious hypothesis that the theories of almost every writer on economical subjects antecedent to the appearance of the works of Child, North, and Locke, in England, and of Gournay and Quesnay, in France, are founded; and, what is of infinitely greater moment, it is on this same hypothesis that the different civilized countries have proceeded to regulate their intercourse with each other. Their grand object has not been to facilitate the production of the necessaries, comforts, and luxuries of life, but to monopolise the largest possible supply of gold and silver. And, as in countries destitute of mines, these could not be obtained except in exchange for exported commodities, various schemes were resorted to for encouraging exportation, and for preventing the importation of almost all products other than the precious metals. In consequence of this opinion, the excess of the value of the exports over the value of the imports was long considered as the most infallible test of the progress of a country in the career of wealth. This excess, it was believed, could not be balanced otherwise than by an equivalent importation of gold or silver, or of the only real wealth which it was then supposed a country could possess.

These principles and conclusions, though absolutely false and erroneous, afford a tolerable explanation of a few very obvious phenomena; and, what did more to recommend them, they are in perfect unison with the popular prejudices on the subject. It was natural, therefore, that they should be espoused by the merchants or practical men, who were the earliest writers on this science. They did not consider it necessary to subject the principles they assumed to any refined analysis or examination. But, reckoning them as sufficiently established by the common consent and agreement of mankind, they directed themselves exclusively to the discussion of the practical measures calculated to give them the greatest efficacy.

Balance of Trade.

"Although a kingdom," says one of the earliest and ablest writers in defence of the mercantile system, "may be enriched by gifts received, or by purchase taken, from some other nations, yet these are things uncertain, and of small consideration, when they happen. The ordinary means, therefore, to increase our wealth and treasure, is by foreign trade, wherein we must ever observe this rule—*to sell more to strangers yearly than we consume of theirs in value.* For, suppose, that when this kingdom is plentifully served with cloth,

Mercantile System.

lead, tin, iron, fish, and other native commodities, we do yearly export the overplus to foreign countries to the value of L. 2,200,000, by which means we are enabled, beyond the seas, to buy and bring in foreign wares for our use and consumption to the value of L. 2,000,000: By this order duly kept in our trading, we may rest assured that the kingdom shall be enriched yearly L. 200,000, which must be brought to us as so much treasure; because that part of our stock which is not returned to us in wares, must necessarily be brought home in treasure." —(Mun's *Treasure by Foreign Trade*, orig. ed. p. 11.)

The gain on our foreign commerce is here supposed to consist exclusively of the gold and silver which, it is taken for granted, must necessarily be brought home in payment of the excess of exported commodities. Mr Mun lays no stress whatever on the circumstance of foreign commerce enabling us to obtain an infinite variety of useful and agreeable products, which it would either have been impossible for us to produce at all, or to produce so cheaply, at home. We are desired to consider all this accession of wealth—all the vast addition made by commerce to the motives which stimulate, and to the comforts and enjoyments which reward the labour of the industrious, as *nothing*, and to fix our attention exclusively on the balance of L. 200,000 of gold and silver! This is much the same as if we were desired to estimate the comfort and advantage derived from a suit of clothes, by the number and glare of the metal buttons by which they are fastened! And yet the rule for estimating the advantageousness of foreign commerce, which Mr Mun has here given, was long regarded by the generality of merchants and practical statesmen as infallible; and such is the inveteracy of ancient prejudices, that even now we are annually congratulated on the excess of our exports over our imports!

Manufacturing System.

But there were other circumstances, besides the erroneous notions respecting the precious metals, which led to the formation of the mercantile system, and to the enacting of regulations restrictive of the freedom of industry. The feudal government established in the countries that had formed the western division of the Roman Empire, degenerated into a system of anarchy and lawless oppression. The princes, who were of themselves totally unable to restrain the usurpations of the greater barons, or to control their violence, endeavoured to strengthen their influence and consolidate their power, by attaching the inhabitants of cities and towns to their interests. For this purpose, they granted them charters, enfranchising the inhabitants, abolishing every existing mark of servitude, and forming them into corporations, or bodies politic, to be governed by a council and magistrates of their own selection. The order and good government that was thus established in the cities, and the security of property enjoyed by their inhabitants, when the rest of the country was a prey to rapine and disorder, stimulated their industry, and gave them a vast ascendancy over the cultivators of the soil. It was from the cities that the princes derived the greater part of their supplies of money; and it was by their assistance and co-operation that they were enabled to control and subdue the pride and independence of the barons. But the citizens did not render this assistance to their sovereigns merely by way of compensation for the original gift of their charters. They were continually soliciting and obtaining new privileges. And it was not to be expected that princes, so very deeply indebted to them, and by whom they must have been regarded as forming by far the most industrious and deserving portion of their subjects, should be at all disinclined to gratify their wishes. To enable them to obtain their provisions cheap, and to carry on their industry to the best advantage, the exportation of corn, and of the raw materials of their manufactures, was strictly prohibited; at the same time that heavy duties and absolute prohibitions were interposed to prevent the importation of manufactured articles from abroad, and to secure the complete monopoly of the home market to the home manufacturers. These, together with the privilege granted to the citizens of corporate towns of preventing any individual from exercising any branch of business until he had obtained leave from them; and the variety of subordinate regulations intended to force the importation of the raw materials required in manufactures, and the exportation of the manufactured goods, form the principal features of the system of public economy adopted, with the view of encouraging manufacturing industry, in every country in Europe, in the fourteenth, fifteenth, sixteenth, and seventeenth centuries. The freedom of industry recognised by their ancient laws was almost totally destroyed. It would be easy to mention a thousand instances of the excess to which this artificial system was carried in England and other countries; but as many of these instances must be familiar to our readers, we shall only observe, as illustrative of its spirit, that by an act passed in 1678, for the encouragement of the English woollen manufacture, it was ordered that all *dead bodies* should be wrapped in a woollen shroud!

But the exclusion of foreign competition, and the monopoly of the home-market, did not satisfy the manufacturers and merchants. Having obtained all the advantage they could from the public, they attempted to prey on each other. Such of them as possessed most influence, procured the privilege of carrying on particular branches of industry to the exclusion of every other individual. This abuse was carried to a most oppressive height in the reign of Elizabeth, who granted an infinite number of new patents. At length, the grievance became so intolerable, as to induce all classes to join in petitioning for its abolition, which, after much opposition on the part of the Crown, by whom the power of erecting monopolies was considered a very valuable branch of the prerogative, was effected by an act passed in the 21st of James I. But this act did not touch any of the fundamental principles of the mercantile or manufacturing system; and the exclusive privileges of all bodies-corporate were exempted from its operation.

In France the interests of the manufacturers were

Mercantile System.

warmly espoused by the justly celebrated M Colbert, minister of finances during the most splendid period of the reign of Louis XIV.; and the year 1664, when the famous tariff, compiled under Colbert's direction, was first promulgated, has been sometimes considered, though improperly, as the real era of the manufacturing system.

These restrictions were zealously supported by the writers in defence of the mercantile system, and the balance of trade. The facilities given to the exportation of home manufactured goods, and the obstacles thrown in the way of their importation from abroad, seemed to them to be particularly well fitted for making the exports exceed the imports, and procuring a favourable balance. Instead, therefore, of regarding these regulations as the offspring of a selfish monopolizing spirit, they looked on them as having been dictated by the soundest policy. The manufacturing and mercantile systems were thus naturally blended together. The acquisition of a favourable balance of payments was the grand *object* to be accomplished; and heavy duties and restrictions on importations from abroad and bounties and premiums on exportation from home, were the *means* by which this object was to be attained! It cannot excite our surprise that a system having so many popular prejudices in its favour, and which afforded a plausible and convenient apology for the exclusive privileges enjoyed by the manufacturing and commercial classes, should have early attained, or that it should still preserve, notwithstanding the overthrow of its principles, a powerful practical influence. Melon and Forbonnais in France,—Genovesi in Italy, —Mun, Sir Josiah Child, Dr Davenant, the authors of the *British Merchant*, and Sir James Stuart, in England—are the ablest writers who have espoused, some with more and some with fewer exceptions, the leading principles of the mercantile system.

"It is no exaggeration to affirm, that there are very few political errors which have produced more mischief than the mercantile system. Armed with power, it has commanded and forbid where it should only have *protected*. The regulating mania which it has inspired has tormented industry in a thousand ways, to force it from its natural channels. It has made each particular nation regard the welfare of its neighbours as incompatible with its own; hence the reciprocal desire of injuring and impoverishing each other; and hence that spirit of commercial rivalry which has been the immediate or remote cause of the greater number of modern wars. It is this system which has stimulated nations to employ force or cunning to extort commercial treaties, productive of no real advantage to themselves, from the weakness or ignorance of others. It has formed colonies that the mother country might enjoy the monopoly of their trade, and force them to resort exclusively to her markets. In short, where this system has been productive of the least injury, it has retarded the progress of national prosperity; every where else it has deluged the earth with blood, and has depopulated and ruined some of those countries whose power and opulence it was supposed it would carry to the highest pitch." (Storch, *Traitè d'Economie Politique*, Tome I. p. 122.)

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The greater attention which began to be paid, in the seventeenth, and in the earlier part of the last century, to subjects connected with finance, commerce, and agriculture, gradually prepared the way for the downfall of the mercantile system. The English writers preceded those of every other country, in pointing out its defects, and in discovering the real nature and functions of money, and the true principles of commerce. The establishment of a direct intercourse with India did much to accelerate the progress of sound opinions. The precious metals have always been one of the most advantageous articles of export to the East.* And when the East India Company was established in 1600, power was given them annually to export *foreign* gold coins or bullion, of the value of L. 30,000. The Company were, however, bound to import, within six months after the return of every voyage, except the first, as much gold and silver as should together be equal to the value of the silver exported by them. But the enemies of the Company contended, that these regulations were not complied with, and that it was contrary *to all principle*, and highly injurious to the public interests, to *permit the exportation of any quantity of bullion*. The merchants and others interested in the India trade, among whom we have to reckon Sir Dudley Digges, whose defence of the Company was published in 1615, Mr Mun, who published a very able pamphlet in defence of the Company in 1621,† Mr Misselden, and more recently, Sir Josiah Child, could not controvert the reasoning of their opponents, without openly impugning some of the commonly received opinions regarding money. In such circumstances, it is easy to see, that prejudice would be forced to give way to interest. At first, however, the advocates of the Company did not contend, nor is there, indeed, any good reason for thinking that they were of opinion that the exportation of gold or silver to the East Indies was beneficial on the single ground that the commodities brought back were of greater value. They contended, that the Company did not export a greater

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* Pliny, when enumerating the spices, silks, and other eastern products imported into Italy, says, "Minimaque computatione millies centena millia sestertium annis omnibus, India et Seres, peninsulaque illa (Arabia) imperia nostro demunt." (*Hist. Nat.* Lib. XII. cap. 18.)

The Emperor Charles V. used to say that the Portuguese, who then engrossed almost the whole commerce of the East, were the common enemies of Christendom, inasmuch as they drained it of its treasure to export it to infidels!—(Misselden *On Free Trade*, p. 24.)

† This pamphlet, which is now become extremely rare, is printed in Purchas's *Pilgrims*, Vol. I. p. 732.

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quantity of bullion than their charter authorized them to do; and they further contended, that this exportation was advantageous, because the commodities imported from India were chiefly *re-exported* to other countries, from whence a greater quantity of bullion was obtained in exchange for them.* But even this was an immense advance in the progress to a sounder theory. *C'est toujours le premier pas qui coute.* The advocates of the Company began gradually to assume a higher tone; and at length boldly contended that bullion was *nothing but a commodity*, and that its exportation ought to be rendered as free as the exportation of any other commodity. Nor were these opinions confined to the partners of the East India Company. They were gradually communicated to others; and many eminent merchants were taught to look with suspicion on several of the received maxims, and were in consequence led to acquire more correct and comprehensive views regarding commercial intercourse. The new ideas ultimately made their way into the House of Commons; and in 1663, the statutes prohibiting the exportation of *foreign coin and bullion* were repealed, and full liberty given to the East India Company, and to private traders, to export the same in unlimited quantities.

In addition to the controversies respecting the East India trade, the discussions to which the foundation of the colonies in America and the West Indies, the establishment of a compulsory provision for the support of the poor, and the acts prohibiting the exportation of wool, and the non-importation of Irish cattle, &c. gave rise, attracted an extraordinary portion of the public attention to questions connected with the domestic policy of the country. In the course of the seventeenth century, a more than usual number of tracts were published on commercial and economical subjects. And although the doctrines of the greater number of the writers are strongly tinctured with the prevailing spirit of the age, it cannot be denied, that several of them have risen above the prejudices of their contemporaries, and have an unquestionable right to be regarded as the founders of the modern theory of commerce; as the earliest teachers of those sound and liberal doctrines, by which it has been shown, that the prosperity of states can never be promoted by restrictive regulations, or by the depression of their neighbours—that the genuine spirit of commerce is inconsistent with the dark and shallow policy of monopoly—and that the *self-interest* of mankind, not less than their duty, requires them to live in peace, and to cultivate friendship with each other.

Mr Mun.

We have already referred to Mr Mun's treatise, entitled *England's Treasure by Foreign Trade.* This treatise was first published in 1664; but there is good reason to suppose that it had been written many years previously. Mr Mun's son, in the dedication to Lord Southampton, prefixed by him to the work, says, that his father "was, *in his time*, famous among merchants," a mode of expression which he would hardly have used, had not a considerable period elapsed since his father's death: and Mr Edward Misselden, in his *Circle of Commerce*, published in 1623, (p. 36), refers to Mr Mun's tract on the East India trade, and speaks of its author as being an accomplished and *experienced* merchant. Perhaps, therefore, we shall not be far wrong if we assume, that this treatise was written so early as 1635 or 1640. At all events, it is certain, that the doctrines which it contains do not differ much from those which he had previously maintained in his pamphlet in defence of the East India Company, and some of the expressions are literally the same with those in the petition presented by that body to Parliament in 1628, which is known to have been written by Mr Mun.† The extract we have previously given, shows that Mr Mun's opinions, in so far as regards the question respecting the *balance of trade*, were exactly the same with those of his contemporaries. But, we believe, he was the first who endeavoured to show, and who has, in point of fact, successfully shown, that a *favourable balance could never be produced by restrictive regulations*:—that the exportation and importation of bullion, coin, and every other commodity, should be freely permitted; —and that violent measures will never bring gold or silver into a kingdom, or retain them in it. (pp. 27, 92, &c. original ed.) Mr Mun also distinctly lays it down, "that those who have wares cannot want money," and that "it is not the keeping of our money in the kingdom, but *the necessity and use of our wares in foreign countries, and our want of other commodities, that causeth the vent and consumption on all sides which causeth a quick and ample trade.*" (p. 43.)‡ Nor are these detached and incidental passages thrown out at random. They breathe the same spirit which pervades the rest of Mr Mun's book, and constitute and form a part of his system. His observations in answer to Malyne's, on some rather difficult questions connected with exchange, are both accurate and ingenious.

Sir Josiah Child.

The first edition of Sir Josiah Child's celebrated work on trade (*A New Discourse of Trade, &c.*) was published in 1668; but it was very greatly enlarged in the next edition, published in 1690. There are many sound and liberal doctrines advanced in this book. The argument to show that colonies do not and cannot depopulate the mother country is as conclusive as if it had proceeded from the pen of Mr

* Those who have not the original pamphlets may consult Macpherson's *History of Commerce*, Vol. II. pp. 297, 315, 511,—Macpherson's *Account of the European Commerce with India*, pp. 94, 104,—and Mr Robert Grant's *Sketch of the History of the Company*, p. 44, where they will find an ample confirmation of what we have stated.

† This petition, and the reasons on which it is founded, were so well esteemed, as to occasion its being reprinted in 1641.

‡ These expressions are in the petition of the Company, presented to Parliament in 1628.

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Malthus; and the just and forcible reasoning in defence of the naturalization of the Jews is highly creditable to the liberality and good sense of the writer, and discovers a mind greatly superior to the prejudices of the age. Sir Josiah has also many good and judicious observations on the bad effects of the laws against *forestalling* and *regrating;* on those limiting the number of apprentices; and on corporation privileges.

When treating of the laws relating to the exportation of wool, Sir Josiah lays it down as an axiom, "That they that can give the best price for a commodity shall never fail to have it by one means or other, notwithstanding the opposition of any laws, or interposition of any power by sea or land; *of such force, subtilty, and violence, is the general course of trade.*"

The radical defect of Sir Josiah Child's *Treatise* consists in the circumstance of its being chiefly written to illustrate the advantages, which he labours to show, would result from forcibly reducing the rate of interest to *four per cent.;* an error into which he had been led by mistaking the low interest of Holland for the principal cause of her wealth, when this low interest was in truth the effect of her comparatively heavy taxation.

It is, however, worthy of remark, that this error was very soon detected. In the same year (1668) that Sir Josiah's *Treatise* first appeared, a tract was published, entitled, *Interest of Money mistaken, or a Treatise, proving that the Abatement of Interest is the Effect and not the Cause of the Riches of a Nation.* The author of this tract maintains the same opinions that were afterwards held by Locke and Montesquieu, that the interest of money does not depend on statutory regulations, but that it varies according to the comparative opulence of a country; or rather according to the comparative scarcity and abundance of money—increasing when the supply of money diminishes, and diminishing when it increases.* Having endeavoured to establish this principle, the author of the tract successfully contends that Sir Josiah Child had totally mistaken the cause of the wealth of the Dutch, of which he shows the lowness of their interest was merely a consequence.

Sir William Petty's Political Anatomy.

In 1672, Sir William Petty published his celebrated tract, entitled, the *Political Anatomy of Ireland.* In this work, the absurdity of the act passed in 1664, prohibiting the importation of cattle, beef, &c. from Ireland into Britain, is ably exposed, and the advantage of an unconstrained internal commerce clearly set forth. "If it be good for England," says Sir William, "to keep Ireland a distinct kingdom, why do not the predominant party in Parliament, suppose the western members, make England beyond Trent another kingdom, and take tolls and customs upon the borders? Or why was there ever any union between England and Wales? And why may not the entire kingdom of England be further cantonised for the advantage of all parties?" (P. 34, ed. 1719.)

The great defect in the writings of Mun, Misselden, Child, and others, did not really consist so much in their notions about the superior importance of the precious metals, or even the balance of trade, as in their notions respecting the superior advantages derived from the importation of durable, rather than of rapidly perishable commodities, and luxuries. This, however, was an extremely natural opinion; and we cannot be surprised that the earlier writers on commerce should not have avoided falling into an error, from which neither the profound sagacity of Locke, nor the strong sense of Mr Harris, have been able to preserve them. But even so early as 1677, the fallacy of this opinion had been perceived. In that year, there appeared a small tract, entitled, *England's Great Happiness; or, a Dialogue between Content and Complaint;* in which the author contends, that the importation of wine, and other consumable commodities, for which there is a demand, in exchange for money, is advantageous; and, on this ground, defends the French trade, which was as loudly declaimed against by the practical men of that day as it is by those of the present. We shall make a short extract from this remarkable tract:

"*Complaint.*—You speak plain; but what think you of the French trade? which draws away our money by wholesale. Mr Fortrey, † whom I have heard you speak well of, gives an account that they get L. 1,600,000 a-year from us.

"*Content.*—'Tis a great sum; but, perhaps, were it put to a vote in a *wise Council*, whether for that reason the trade should be left off, 'twould go *in the negative.* For paper, wine, linen, Castile soap, brandy, olives, capers, prunes, kidskins, taffaties, and such like, we cannot be without; and for the rest, which you are pleased to style *Apes* and *Peacocks* (although wise Solomon ranked them with gold and ivory), they set us all agog, and have increased among us many considerable trades. * * I must confess, I had rather they'd use our goods than money; but if not, I WOULD NOT LOSE THE GETTING OF TEN POUND BECAUSE I CAN'T GET AN HUNDRED; and I don't question but when the French get more foreign trade, they'll give more liberty to the bringing in foreign goods. I'll suppose John-a-Nokes to be a butcher,

* It has been generally supposed that Mr Hume was the first who showed (in his *Essay on Interest*) the fallacy of this opinion, and who proved that the rate of interest did not depend on the abundance or scarcity of money, but on the abundance or scarcity of disposable capital compared with the demands of the borrowers, and the rate of profit. This, however, is a mistake, the doctrine in question having been fully demonstrated in a pamphlet written by Mr Massie, entitled, *Essay on the Governing Causes of the Natural Rate of Interest*, published two years before Mr Hume's *Essay* appeared.

† Mr Fortrey's pamphlet has been much referred to. It was published in 1663, and reprinted in 1673. It contains a very good argument in favour of inclosures. The reference in the text sufficiently explains the opinions of the writer in regard to commerce.

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Dick-a-Styles to be an Exchange man, yourself a lawyer, *will you buy no meat or ribbands, or your wife a fine Indian gown or fan, because they will not truck with you for indentures which they have need of?* I suppose no; but if you get money enough of others, you care not though you give it away *in specie* for these things; I think 'tis the same case."

The general spirit of this tract may perhaps be better inferred from the titles of some of the dialogues. Among others, we have "*To export money our great advantage;*"—"*The French trade a profitable trade;*"—"*Variety of wares for all markets, a great advantage;*"—"*High living, a great improvement to the arts;*"—"*Invitation of foreign arts, a great advantage;*"—"*Multitudes of traders, a great advantage,*" &c. &c. But its influence was far too feeble to arrest the current of popular prejudice. In the year after its publication (1678) the importation of French commodities was prohibited for three years. This prohibition was made perpetual in the reign of William III. when the French trade was declared a *nuisance!*—a principle, if we may so call it, which has been acted upon to this very hour.

In 1681, a pamphlet was published in defence of the East India Company, under the signature of "Philopatris," but evidently the production of Sir Josiah Child. In the introduction to this pamphlet, the following general principles are laid down:—

"That all *close monopolies* (Sir Josiah contends that the East India Company does not come under this description), *of what nature or kind soever, are destructive to trade*, and consequently obstructive to the increase of the value of our lands."

"That silver or gold, coined or uncoined, though they are used for a measure of all other things, *are no less a commodity than wine, oil, tobacco, cloth, or stuffs;* and may, in many cases, be *exported as much to the national advantage as any other commodity.*"

"That no nation ever was, or will be, considerable in trade, that prohibits the exportation of bullion." (p. 3.)

Sir William Petty's Quantulumcunque.

In Sir William Petty's *Quantulumcunque*, published in 1682, the subject of money is treated with great ability, and the idea of draining England of her cash, by an unfavourable balance, successfully combated. "If some English merchants," it is said, "should be so improvident as to carry out money only, then the foreign merchants would buy up such English commodities as they wanted with money brought into England from their respective countries, or with such commodities as England likes better than money; *for the vending of English commodities doth not depend on any thing else but the use and need which foreigners have of them.*" Sir W. denies that "*a country is the poorer for having less money;*" and concludes by strongly condemning the laws regulating the rate of interest; observing, that there may as well be laws to regulate the rate of exchange and of insurance. (See pp. 3, 6, 8, original edition.)

Sir Dudley North.

But a tract, entitled, *Discourses on Trade, principally directed to the Cases of Interest, Coinage, Clipping, and Increase of Money*, written by Sir Dudley North, and published in 1691, unquestionably contains a far more able statement of the true principles of commerce than any that had then appeared.

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We regret that our limits will not permit our giving so full an account as we could have wished of this extraordinary tract. The author is a most intelligent and *consistent* advocate of the great principles of commercial freedom. He is not, like the most eminent of his predecessors, well informed on one subject, and erroneous on another. He is throughout sound and liberal. His system is consentaneous in its parts, and complete. He shows, that in commercial matters, nations have the same interests as individuals; and exposes the absurdity of supposing, that any trade which is advantageous to the merchant can be injurious to the public. His opinions respecting the imposition of a seignorage on the coinage of money, and the expediency of sumptuary laws, then in great favour, are equally enlightened.

We subjoin from the preface to this tract an abstract of the general propositions maintained in it:

"THAT THE WHOLE WORLD AS TO TRADE IS BUT AS ONE NATION OR PEOPLE, AND THEREIN NATIONS ARE AS PERSONS.

"That the loss of a trade with one nation is not that only, separately considered, but so much of the trade of the world rescinded and lost, for all is combined together.

"THAT THERE CAN BE NO TRADE UNPROFITABLE TO THE PUBLIC; FOR IF ANY PROVE SO, MEN LEAVE IT OFF; AND WHEREVER THE TRADERS THRIVE, THE PUBLIC, OF WHICH THEY ARE A PART, THRIVE ALSO.

"That to force men to deal in any prescribed manner may profit such as happen to serve them; but the public gains not, because *it is taking from one subject to give to another.*

"That no laws can set prices in trade, the rates of which must and will make themselves. But when such laws do happen to lay any hold, it is so much impediment to trade, and therefore prejudicial.

"*That money is a merchandise, whereof there may be a glut, as well as a scarcity, and that even to an inconvenience.*

"THAT A PEOPLE CANNOT WANT MONEY TO SERVE THE ORDINARY DEALING, AND MORE THAN ENOUGH THEY WILL NOT HAVE.

"That no man will be the richer for the making much money, nor have any part of it, but as he buys it for an equivalent price.

"*That the free coynage is a perpetual motion found out, whereby to melt and coyn without ceasing*, and so to feed goldsmiths and coyners at the public charge.

"That debasing the coyn is defrauding one another, and to the public there is no sort of advantage from it; for that admits no character, or value, but intrinsick.

"That the sinking by alloy or weight is all one.

"*That exchange and ready money are the same, nothing but carriage and re-carriage being saved.*

"That money exported in trade is an increase to the wealth of the nation; *but spent in war, and payments abroad, is so much impoverishment.*

"In short, that ALL FAVOUR TO ONE TRADE, OR INTEREST, IS AN ABUSE, AND CUTS SO MUCH OF PROFIT FROM THE PUBLIC."

Unluckily this admirable tract never obtained any considerable circulation. There is good reason, in-

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deed, to suppose that it was designedly suppressed.* At all events, it speedily became excessively scarce; and we are not aware that it has ever been referred to by any subsequent writer on commerce.

Mr Locke.

The disordered state of the coin, and the proceedings relative to the great recoinage in the reign of William III., led to a great deal of discussion both in and out of Parliament, and contributed, in no ordinary degree, to diffuse juster notions respecting money and commerce. It was then that Mr Locke published his well known tracts on Money.† These tracts immediately obtained a very extensive circulation; and though infected with some very grave errors, they had a powerful influence in preventing Mr Lowndes's proposal for degrading the standard of the coin from being carried into effect, and in contributing to establish the true theory of money. The restoration of the currency was not, however, effected without great opposition. A large minority in Parliament supported Mr Lowndes's views; and they were also supported by a number of writers. Of these,

Mr Barbon.

Mr Nicholas Barbon seems to have been one of the ablest. In his tract, entitled, *A Discourse concerning Coining the New Money Lighter*, published in 1696, he detected several of the errors into which Mr Locke had fallen; and he has the further merit of having ably demonstrated the fallacy of the popular opinions respecting the balance of trade; and of having shown, that no bullion could ever be sent abroad in payment of an unfavourable balance, unless it was at the time the cheapest and most profitable article of export.

The inferences deduced by Mr Barbon from his investigations into the balance of trade and foreign exchange are:

"That a trading nation is made rich by traffic and the industry of the inhabitants—and that the native stock of a nation can never be wasted.

"That no sort of commodities ought to be totally prohibited—*and that the freer trade is, the better the nation will thrive.*

"That the poverty and riches of a nation does not depend on a lesser or greater consumption of foreign trade, nor on the difference of the value of those goods that are consumed.

"That the balance of trade is a notion that serves rather to puzzle all debates of trade, than to discover any particular advantages a nation may get by regulating of trade.

"*That the balance of trade (if there be one) is not the cause of sending away the money out of a nation: But that proceeds from the difference of the value of bullion in several countries, and from the profit that the merchant makes by sending it away more than by bills of exchange.*

"That there is no occasion to send away money or bullion to pay bills of exchange, or balance accounts.

"That all sorts of goods, of the value of the bill of exchange, or the balance of the account, will answer the bill, and balance the account as well as money."—(p. 59.)

It is singular, that a writer possessed of such sound and enlarged opinions respecting the principles of commercial intercourse, and who had shown that bullion differed in no respect from other commodities, should have maintained, that the value of *coined money* chiefly depended on *the stamp affixed to it by government.* This gross and unaccountable error destroyed the effect of Mr Barbon's tract; and was, most probably, the cause of the oblivion into which it very soon fell, and of its never having attracted that attention to which it was on other accounts justly entitled.

Dr Davenant.

The commercial writings of Dr Davenant, Inspector-General of Imports and Exports in the reign of Queen Anne, were published in the interval between 1695 and 1711. Though a partizan of the mercantile system, Dr Davenant had emancipated himself from many of the prejudices of its more indiscriminate and zealous supporters. He considers a watchful attention to the balance of trade, and its "right government," as of the highest importance; but he does not consider wealth as consisting exclusively of gold or silver; or that prohibitions and restrictions should be rashly imposed, even on the intercourse with those countries with which the balance is supposed to be unfavourable. But we are far from thinking, that the commercial writings of Dr Davenant deserve the eulogies that have been bestowed on them; or that they had any material effect in accelerating the progress of sound commercial science. They do not, in fact, contain a single principle that is not to be found in the work of Sir Josiah Child. Some of Dr Davenant's paragraphs are exceedingly good; but the treatises of which they form a part are remarkably inconclusive, and are for the most part founded on narrow and contracted principles. There is no evidence to show that Dr Davenant was at all aware of the effect of commerce in facilitating the production of wealth, by enabling the inhabitants of each particular country to devote themselves, in preference, to those employments for the successful prosecution of which they have some natural advantage.‡

Jacob Vanderlint.

In 1734, Jacob Vanderlint, who describes him-

* See the Honourable Roger North's *Life* of his brother, the Honourable Sir Dudley North, p. 179.

† *Considerations on the Lowering of Interest and Raising the Value of Money*, 1691. *Further Considerations concerning Raising the Value of Money*, 1695.

‡ The progress of enlarged and liberal opinions with regard to commerce seem to have been in no small degree counteracted by the publication of the *British Merchant.* This work was written by some of the first merchants of their time, and was chiefly intended to expose the alleged defects in the commercial treaty with France negotiated by Queen Anne's Tory administration in 1713. It consists of a series of papers published weekly, and afterwards collected in three volumes. Public opinion being very much against the treaty, the *British Merchant* enjoyed a large share of popularity. Its authors appear to have

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self as a tradesman, published his tract, entitled, *Money answers all Things*. Mr Stewart has referred to this tract in the *Appendix* to his valuable *Life of Dr Smith*, and has quoted some passages, illustrative of the advantages of commercial freedom, which, he truly says, "will bear a comparison, both in point of good sense and of liberality, with what was so ably urged by Mr Hume twenty years afterwards, in his *Essay on the Jealousy of Trade*." Vanderlint closes his pamphlet with an argument in favour of the substitution of a territorial tax in place of every other—an idea borrowed from Locke, and subsequently adopted by the French economists.

Sir Matthew Decker.

In 1744,* Sir Matthew Decker, an extensive merchant, published his *Essay on the Causes of the Decline of Foreign Trade*. This essay has been frequently referred to by Dr Smith, and it deserved his notice. Sir Matthew is a most intelligent and decided enemy of all *restrictions, monopolies, and prohibitions whatever*. To give full freedom to industry—he proposes that all *corporation privileges* should be abolished; and that all the existing taxes should be repealed, and replaced by a *single tax* laid on the consumers of luxuries, proportionally to their incomes. The following short extracts will give an idea of the spirit and ability which pervades Sir Matthew's work:—

"In the *Memoirs of De Witt*, is is said, '*that restraint is always hurtful to trade*;' the reason whereof is plain; *for nature has given various products to various countries, and thereby knit mankind in an intercourse to supply each other's wants*. To attempt to sell our products, but to buy little or none from foreigners, is attempting an impossibility, acting contrary to the intent of nature, cynically, and absurdly; and, as ours is a populous manufacturing country, might be prejudicial to our interests; for, could we raise all necessaries and vanities within ourselves, this intercourse designed by nature would be destroyed; and then, how is our navy, our only bulwark, to be maintained?" (p. 147.)

"Trade cannot, will not, be forced; let other nations prohibit, by what severity they please, interest will prevail; they may embarrass their own trade, but *cannot hurt a nation, whose trade is free, so much as themselves*. Spain has prohibited our woollens; but had a reduction of our taxes brought them to their natural value only, they would be the cheapest in Europe of their goodness, consequently must be more demanded by the Spaniards, be smuggled into their country in spite of their government, and sold at better prices; their people would be dearer clothed, with duties and prohibitions, than without, consequently must sell their oil, wine, and other commodities, dearer; whereby other nations, raising the like growths, would gain ground upon them, and their balance of trade grow less and less. But should we, for that reason, prohibit their commodities? By no means; for the dearer they grow, no more than what are just necessary will be used; *their prohibition does their own business*; some may be necessary for us; *what are so, we should not make dearer to our own people*; some may be proper to assort cargoes for other countries, and why should we prohibit our people that advantage? WHY HURT OURSELVES TO HURT THE SPANIARDS? If we would retaliate effectually upon them for their ill-intent, handsome premiums given to our plantations to raise the same growths as Spain might enable them to supply us cheaper than the Spaniards could do, and establish a trade they could never recover. Premiums may gain trade, but *prohibitions will destroy it*." (p. 163.)

Sir Matthew applies the same argument to expose the absurdity and injurious effect of our restraints on the trade with France. "I allow," he says, "that Britain should be always vigilant over the designs of France, but need not be afraid of her power; her wise regulations in trade should be the objects we should keep our eyes upon, and out-do her if possible; or else, as she rises, we must sink. But it is our comfort, that our remedy is always in our own hands; nor can there be any solid reason for the nation's paying dearer to other countries for goods we could buy cheaper in France. Would any wise dealer in London buy goods of a Dutch shopkeeper for 15d. or 18d. when he could have the same from a French shopkeeper for 1s.? Would he not consider, that, by so doing, he would empty his own pockets the sooner, and that, in the end, he would greatly injure his own family by such whims? And *shall this nation commit an absurdity that stares every private man in the face?* —— The certain way to be secure is to be more powerful, that is, to extend our trade as far as it is capable of; and as restraints have proved its ruin, to reject them, and *depend on freedom for our security*; bidding defiance to the French, or any nation in Europe, that took umbrage at our exerting our natural advantages." (p. 184.)

We do not know that the impolicy of restrictions on the importation of *foreign corn* has ever been more ably and triumphantly exposed than in the following passage: "Every home commodity, in a free trade, will find its natural value; for, though that fluctuates, as of necessity it must, according to the plentifulness or scarcity of seasons, yet, for the home consumption, every home commodity must have great advantage over the foreign, as being upon the spot, and free from freight, insurance, commission, and charges, which on the produce of lands, being all bulky commodities, must in general be about 15 *per cent.*, and a greater advantage cannot be given without prejudice; for 15 *per cent.* makes a great difference in the price of necessaries between the nation selling and the nation buying, and is a great difficulty on the latter, but, arising from the natural course of things, cannot be helped; though it *is a sufficient security to the landholder, that foreigners can never import more necessaries than are absolutely required;*

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been thoroughly imbued with all the prejudices of the mercantile sect; and the work is now only deserving of notice as containing the fullest exposition of their peculiar doctrines.

* We quote from the edition of the *Essay* published at Edinburgh in 1756. It appears from the work itself (p. 4), that it had been written in 1740; the first edition was in 4to.

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and, I presume, in such cases, they have more charity than to starve the people merely for an imaginary profit, which yet would prove their ruin in the end; for *it is a fallacy and an absurdity to think to raise the value of lands by oppressions on the people that cramp their trade;* for if trade declines, the common people must either come upon the parish, or fly for business to our neighbours: in the first case, they become a heavy tax on the rich, and instead of buying the produce of their lands, must have it given them; and in the second case, when the consumers are gone, what price will the produce of land bear?" (p. 56.)

Mr Hume.

Of a work so well known as Mr Hume's *Political Essays* (published in 1752) it is almost superfluous to speak. The ability with which he has combated the prejudice against the French trade, and exposed the absurdity of the dread of being deprived of a sufficient supply of bullion; the liberality and expansion of his views respecting commerce in general; and the beauty of his illustrations, cannot be too highly praised. It did not, however, enter into Mr Hume's plan to give a systematic view of the effects of commerce, nor has he instituted any analysis of the sources of wealth.

Mr Harris.

Mr Harris has endeavoured to supply the latter deficiency; and his *Essay upon Money and Coins*, published in 1757, is, perhaps, on the whole, the best economical treatise that had appeared previously to the publication of the *Wealth of Nations*. We have already noticed Mr Harris's mistake of supposing that it was more profitable to import durable rather than rapidly consumable commodities; and, as a writer on commerce, he is undoubtedly very inferior to Sir Dudley North and Sir Matthew Decker. But the comprehensive and able manner in which he has treated the subject of money; the skill with which he has illustrated the effects of the division of labour in facilitating production and increasing wealth; and the near approach he has made to some of the fundamental doctrines of Dr Smith, if they do not give him a pre-eminence, certainly place him in the first rank among his precursors.

Early Italian Writers on Commerce.

We have been induced to treat of the progress of commercial science in England at considerable length, partly on account of the interest and importance of the subject, and partly because we are not acquainted with any work in which it has been investigated. M. Say and some other continental writers contend, that the Italians and French were the first who discovered and established the just principles of commercial intercourse. But the details we have now given prove the indisputable priority of the English. The economical works of Davanzati, Serra, Turbolo, and Scaruffi, are almost wholly occupied with a discussion of the effects of a forced reduction of the standard of money. They deserve credit for having opposed all tampering with the currency; but the arguments they employ to show its injustice and impolicy, are stated with much greater brevity and force in Sir Robert Cotton's speech in the Privy Council in 1626. The *Discurso Economico* of Bandini, the earliest writer on commerce whose works have been thought worthy of a place in the voluminous collection of Italian works on Political Economy, * was published so late as 1737. Belloni and Algarotti's *Essays on Commerce*, both very inferior to the works of Sir Josiah Child or Sir Dudley North, were published, the former in 1750, and the latter in 1763.

Early French Writers on Commerce.

The French have still less claim than the Italians to be considered the discoverers of the true principles of commerce. There is much accurate observation, and many just, patriotic, and striking observations on the injury France sustained from the want of a free internal traffic, and from the oppressiveness of taxation, in the *Dixme Royale* of the famous Marshal Vauban, written in 1698. But Vincent de Gournay, whom the French state to be one of the earliest of their authors, who entertained comprehensive and liberal notions regarding commerce in general, was born so late as 1712. † M. Gournay published translations of the treatise of Sir Josiah Child, and of a tract of Sir Thomas Culpepper's, at Paris in 1752. So slow was the progress of economical science in France, that even Montesquieu has a chapter entitled, "*A quelles nations il est desavantageux de faire le commerce.*" ‡

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But neither the efforts of the English nor French

* *Scrittori Classici Italiani di Economia Politica.* The publication of this collection of the works of her economical writers does honour to Italy. It was begun in 1803 and finished in 1805, in 50 volumes, 8vo.

† See Dupont's edition *Des Oeuvres de M. Turgot*, Tom. III. p. 311.

‡ Maupertuis, in his *Eloge of Montesquieu*, candidly admits that France is indebted for the science of commerce, finance, and population, or of Political Economy, to England. The passage is curious: "Comme le plan de Montesquieu," he observes, "renfermoit tout ce qui peut etre utile au genre humain, il n'a pas oublié cette partie essentielle qui regarde le commerce, les finances, la population: Science *si nouvelle parmi nous*, qu'elle n'y a encore point de nom.—C'est *chez nos voisins qu'elle est née; et elle y demeura jusque à ce que M. Melon lui fit passer le mer.*"

Melon's work, *Essai Politique sur le Commerce*, was published in 1734.—It is entirely founded on the principles of the mercantile system. Mr Bindon translated it into English, and published it, along with some rather valuable annotations and remarks, at Dublin in 1739.

Melon had advocated the ruinous policy of raising the denomination of the coin. This gave occasion to the publication of a very acute work by Dutot, entitled, *Reflexions Politiques sur les Finances et le Commerce*, 2 Tomes, 12mo. 1738. Dutot's work was in its turn very ably criticised by Duverney, in his *Examen des Reflexions Politiques sur le Finances*, &c. 2 Tomes, 12mo. 1740. These works contain a great deal of very curious and interesting information respecting the French finances. Duverney's account of the famous *Mississippi Scheme* is particularly good.

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writers in favour of the freedom of commerce and industry had any considerable influence on the mercantile system. Their opinions respecting the nature of wealth, and of the causes of national opulence, being confused and contradictory, their arguments in favour of a liberal system of commerce had somewhat of an empirical appearance, and failed of making that impression which is always made by arguments founded on well established principles, and shown to be consistent with experience. Mr Locke, as we shall hereafter show, unquestionably entertained very correct opinions respecting the paramount influence of labour in the production of wealth; but he did not prosecute his investigations with the view of elucidating the principles of this science, and made no reference to them in his subsequent writings. Mr Harris adopted Mr Locke's views, and deduced from them some practical inferences of great importance; but his general reasonings are merely introductory to his *Treatise on Money*, and are not illustrated with that fulness of detail, or in that comprehensive and systematic manner that is necessary in scientific works. The celebrated M. Quesnay, a physician, attached to the court of Louis XV., has the unquestionable merit of being the first who attempted to investigate and analyze the sources of wealth, *with the intention of ascertaining the fundamental principles of Political Economy*, and who gave it a systematic form, and raised it to the rank of a science. Quesnay's father was a small proprietor, and having been educated in the country, he was naturally inclined to regard agriculture with more than ordinary partiality. At an early period of his life he had been struck with its depressed state in France, and had set himself to discover the causes which had prevented its making that progress which the industry of the inhabitants, the fertility of the soil, and the excellence of the climate, seemed to insure. In the course of this inquiry, he speedily discovered that the prohibition of exporting corn to foreign countries, and the preference given by the regulations of Colbert to the manufacturing and commercial classes over the agriculturists, had been one of the most powerful obstacles to the progress and improvement of agriculture. But Quesnay did not satisfy himself with exposing the injustice of this preference, and its pernicious consequences. His zeal for the interests of agriculture led him, not merely to place it on the same level with manufactures and commerce, but to raise it above them, by endeavouring to show that it was the only species of industry which contributed to increase the riches of a nation. Founding on the indisputable fact, that every thing which either ministers to our wants, or gratifies our desires, must be originally derived from the earth, Quesnay assumed as a self-evident truth, that the earth was the only *source* of wealth; and held that industry was altogether incapable of producing any new value, except when employed in agriculture, including therein fisheries and mines.* His observation of the striking effects of the *vegetative powers of nature*, and his inability to explain the real origin and causes of rent, confirmed him in this opinion. The circumstance, that of all who are engaged in laborious undertakings, none but the cultivators of the soil paid rent for the use of *natural agents*, appeared to him an incontrovertible proof, that agriculture was the only species of industry which yielded a net surplus (*produit net*) over and above the expences of production. Quesnay allowed that manufacturers and merchants were highly useful; but, as they realised no net surplus in the shape of rent, he contended they did not add any greater value to the raw material of the commodities they manufactured or carried from place to place, than what was just equivalent to the value of the capital or stock consumed by them. These principles once established, it followed that landlords, farmers, and labourers employed in agriculture, were the only *productive* classes in a state; and that the labour of manufacturers and traders being *unproductive*, their means of subsistence, and their wealth, could only be derived from the agriculturists. It further followed, that the expences of government, and the various public burdens, however imposed, must be defrayed out of the *produit net*, or rent of the landlords; and, consistently with this principle, Quesnay proposed that all the existing taxes should be repealed, and that a single tax *(l'Impot unique)*, levied directly from the produce of the land, should be imposed in their stead.

M. Quesnay.

The *economical table* of M. Quesnay—" Cette formule ettonnante," says Dupont, " qui peint la naissance, la distribution, et la reproduction des richesses, et qui sert à calculer avec tant de sureté, de promptitude, et de precision, l'effet de toutes les operations relatives aux richesses"—was first published at Versailles in 1758.

But, however much impressed with the importance of agriculture over every other species of industry, Quesnay did not solicit for it any exclusive favour or protection. He successfully contended that the interests of the agriculturists, and of all the other classes, would be best promoted by establishing a system of perfect freedom. He showed that it could never be the interest of the proprietors and cultivators of the soil to fetter or discourage the industry of merchants, artificers, and manufacturers: for the greater the liberty which they enjoyed, the greater would be their competition, and their products would, in consequence, be sold so much the cheaper. Neither, on the other hand, could it ever be the interest of the unproductive classes to harass and oppress the industry of the agriculturists, either by preventing the free exportation of their products, or by

* " Cherchant d'ou vient les richesses des nations, Quesnay trouva qu'elles ne naissent que des travaux dans lequels la *Nature et la Puissance Divine,* concourent avec les efforts pour produire on faire recueillir des productions nouvelles: de sorte qu'on ne peut attendre l'augmentation des ces richesses que de la cultivation, de la pêche, et de l'exploitation des mines et des carrieres." (See the *Notice sur les Economistes*, by one of the most zealous of the sect, *Dupont de Nemours*, in the *Œuvres de Turgot*, Tome III. p. 312.)

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any restrictive regulations whatsoever. When the cultivators enjoy the greatest degree of freedom, their industry, and, consequently, their *surplus produce*—the only fund from which any accession of national wealth can be derived, will be carried to the greatest possible extent. According to this "liberal and generous system" (*Wealth of Nations*, Vol. III. p. 17), the establishment of perfect liberty, perfect security, and perfect justice, is the only, as it is the infallible, means of securing the highest degree of prosperity to all classes of the society.

"Ou a vu," says the Commentator of this system, M. Mercier de la Riviere, "qu'il est de l'essence de l'ordre que l'interet particulier d'un seul ne puisse jamais etre separée de l'interet commun de tous ; nous en trouvons une preuve bien convaincante dans les effets que produit naturellement et necessairement la plénitude de la liberté qui doit regner dans le commerce, pour ne point blesser la propriété. L'interet personnel encouragée par cette grande liberté, presse vivement et perpetuellement châque homme en particulier, de perfectionner, de multiplier les choses dont il est vendeur ; de grossir ainsi la masse des jouissances qu'il peut procurer aux autres hommes, afin de grossir, par ce moyen, la masse des jouissances que les autres hommes peuvent lui procurer en echange. *Le monde* alors *va de lui meme ;* le desir de jouir, et la liberté de jouir ne cessant de provoquer la multiplication des productions et l'accroissement de l'industrie, ils impriment à toute la société, un mouvement qui devient une tendance perpetuelle vers son meilleur etat possible."—(Tome II. p. 444.)*

We shall have other opportunities of fully examining the principles of this theory. At present, it is sufficient to remark, that, in assuming agriculture to be the only source of wealth, because the matter of which all commodities are composed must be originally derived from the earth, M. Quesnay and his followers mistake altogether the nature of production, and really suppose wealth to consist of matter. But, in its natural state, matter is very rarely possessed of utility, and is always destitute of value. It is only by means of the *labour* bestowed in the appropriation of matter, and in fitting and preparing it for our use, that it acquires exchangeable value, and becomes wealth. Human industry does not produce wealth by making any additions to the matter of our globe ; for this is a quantity susceptible neither of augmentation nor diminution. Its real effect is simply to produce wealth *by giving utility to matter already in existence ;* and we shall hereafter show that the labour employed in manufactures and commerce is just as productive of utility, and consequently of wealth, as the labour employed in agriculture. Neither is the cultivation of the soil, as M. Quesnay supposed, the only species of industry which yields a surplus produce over the expences of production. When none but the best soils are cultivated, and when, consequently, agriculture is most productive, no rent, or *produit net*, is obtained from the land ; and it is only after recourse has been had to poorer soils, and when the productive powers of the labour and capital employed in cultivation begin to diminish, that rent begins to appear. So that, instead of being a consequence

* That M. Quesnay is entitled to the merit of originality cannot, we think, be disputed. It is certain, however, that he had been anticipated in several of his peculiar doctrines by some English writers of the previous century. The fundamental principles of the economical system are distinctly and clearly stated in a tract entitled *Reasons for a limited Exportation of Wool*, published in 1677. "That it is of the greatest concern and interest of the nation," says the author of the tract, "to preserve the nobility, gentry, and those to whom the land of the country belongs, at least, much greater than a few artificers employed in working the superfluity of our wool, or the merchants who gain by the exportation of our manufactures, is manifest—1. Because they are the *masters and proprietaries of the foundation of all the wealth in this nation, all profit arising out of the ground which is theirs.* 2. *Because they bear all taxes and public burdens ;* which, in truth, are only born by those who buy, and sell not; all sellers, raising the price of their commodities, or abating of their goodness, according to their taxes."—(Not being able to procure the pamphlet itself, we quote from the extract given in Mr Smith's *Memoirs of Wool*, Vol. I. p. 254.)

In 1696, Mr Asgill published a treatise entitled *Several Assertions Proved, in order to Create Another Species of Money than Gold*, in support of Dr Chamberlayne's proposition for a Land Bank. We extract from this treatise the following passage, breathing, as Mr Stewart has justly observed, the very spirit of Quesnay's philosophy :—

"What we call commodities is nothing but land severed from the soil—*Man deals in nothing but earth.* The merchants are the factors of the world, to exchange one part of the earth for another. The king himself is fed by the labour of the ox : and the clothing of the army and victualling of the navy must all be paid for to the owner of the soil as the ultimate receiver. All things in the world are originally the produce of the ground, and there must all things be raised."—(This passage has been quoted in Lord Lauderdale's *Inquiry into the Nature and Origin of Public Wealth*, 2d ed. p. 109.)

These passages are interesting, as exhibiting the first germs of the theory of the Economists. But there is no reason whatever to suppose that Quesnay was aware of the existence of either of the tracts referred to. The subjects treated in them were of too local a description to excite the attention of foreigners ; and Quesnay was too candid to conceal his obligations to them, had he really owed them any. It is probable he may have seen Mr Locke's treatise on *Raising the Value of Money*, where the idea is thrown out that all taxes fall ultimately on the land. But there is an immeasurable difference between the suggestion of Locke and the well digested system of Quesnay.

System of the French Economists.

of the superior productiveness of agricultural industry, rent is really a consequence of its being less productive! The opinion of M. Quesnay, that the labour of man derives no assistance from the productive powers of nature, except when employed in agriculture, is totally destitute of foundation; and, in a subsequent part of this article, we shall show that the manufacturer and merchant derive fully as much assistance from these powers as either the agriculturist, the fisher, or the miner.

Though the theory of the French economists, considered in reference to the fundamental principles of the science, was equally erroneous with that to which it was opposed, its novelty and ingenuity, its systematic and consentaneous form, the liberal system of commercial intercourse which it recommended, and the benevolent and excellent character of its founder, speedily obtained for it a very high degree of reputation. The opinions of M. Quesnay were early communicated to, and zealously espoused by, his friends the Marquis de Mirabeau, M. Mercier de la Riviere, M. Dupont de Nemours, and others; and were afterwards advocated by Turgot, one of the most distinguished statesmen of whom France has to boast;* and by Letrosne, Condorcet, Raynal, and most of the succeeding French writers on commerce and finance. Their practical influence on the legislation of the country has also been considerable. In 1763 the free transportation of corn from one province to another was permitted; and in 1764 liberty was given to export it to foreign countries whenever the home price did not exceed 30 livres the septier (48s. the quarter). This last edict, after being suspended in 1770, was again revived in 1778 under the administration of Turgot. But the facility given to the imposition of the *contribution fonciere*, ought certainly to be considered as the greatest practical achievement of the labours of the economists; and there is but too much reason to fear it will long continue to afford a palpable demonstration of the fallacy of their doctrines. †

System of the French Economists.

But, notwithstanding the defects of their theory, there can be no question that the labours of the French economists contributed powerfully to accelerate the progress of economical science. In reasoning on subjects connected with national wealth, it was now found to be necessary to subject its sources, and the laws which regulate its production and distribution, to a more accurate and searching analysis. In the course of this examination, it was speedily ascertained that both the mercantile and economical theories were erroneous and defective; and that to establish the science of Political Economy on a firm foundation, it was necessary to take a much more extensive survey, and to seek for its principles, not in a few partial and distorted facts, or in metaphysical abstractions, but in the connection and relation subsisting among the various phenomena manifested in the progress of civilization. The Count di Verri, whose *Meditations on Political Economy* were published in 1771, demonstrated the fallacy of the opinions entertained by the French economists respecting the superior productiveness of the labour employed in agriculture; and showed that all the operations of industry really consist of *modifications of matter already in existence.* ‡ But Verri

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* Turgot's *Reflexions sur la Formation, et la Distribution des Richesses* published in 1771, is certainly the best of all the works founded on the principles of the economists; and is, in some respects, the best work on Political Economy published previously to the *Wealth of Nations.*

† Exclusive of the *Reflexions* of Turgot, the following are the principal works published by the French Economists:—

Tableau Economique, et Maximes Generales du Gouvernement Economique, par Francois Quesnay, 4to. Versailles, 1758.

Theorie de l'Impot, par M. de Mirabeau, 4to, 1760.

L'Ami des Hommes, par M. de Mirabeau, 7 Tomes, 1760, &c.

Elements de la Philosophie Rurale, par M. de Mirabeau, 3 Tomes, 12mo, 1763.

L'Ordre Naturel et Essentiel des Societes Politiques, par Mercier de la Riviere, 4to, and 2 Tomes 12mo, 1767.

Sur l'Origine et Progrès d'une Nouvelle Science, par Dupont de Nemours, 1767.

La Physiocratie, ou Constitution Naturelle du Gouvernement le plus avantageux aux genre humain, par Quesnay, 2 Tomes, 1767.

Lettres d'un Citoyen à un Magistrat, sur les vingtiemes et les autres impots, par l'Abbe Baudeau, 1768.

‡ Alcuni benemeriti scrittori, rattristati dai gravi disordini, che soffrono i popoli per le gabelle, sono passati all'estremo de considerare ingiusto e mal collocato il tributo se non ripartito sui fondi di terra, e colla creazione di un linguaggio ascetico, hanno eretta la setta degli economisti, presso la quale ogni uomo che non adoperi l'aratro, e un essere sterile, e i mamifattori si chiamano una *classe sterile.* Rispettando il molto di vero e di utile che da essi è stato scritto, io non saprei associarmi alla loro opinione ne sul tributo, ne su di questa pretesa classe sterile. La riproduzione e attribuibile alla manifattura ugualmente, quanto al laroro de campi. Tutti i fenomini dell' universo, sieno essi prodotti dalla mano dell'uomo o vero dalle universali leggi della fisica, non ci danno idea di attuale *creazione,* ma unicamente di una *modificazione* della materia. *Accostare e seperare* sono gli unici elementi che l'ingegno umano ritrova analizando l'idea della *riproduzione;* e tanto e riproduzione *di valore e di richezza* se la terra, l'aria, e l'aqua ne'campi si trasmutino in grano, come se colla mano dello uomo il glutine di un insetto si trasmuti in velluto, o vero alcuni pezzetti di metallo si organizzino a formare una ripetizione. Degli intieri citta, e degli stati intieri campano non d'altro che sul prodotto di questa fecondissima *classe sterile,* la di cui riproduzione comprende il valore della materia prima, la consumazione proporzionata delle mani impiegatevi, e di piu quella porzione

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did not trace the consequences of this important principle; and, possessing no clear and definite notions of what constituted wealth, did not attempt to discover the means by which labour might be facilitated. He made several valuable additions to particular branches of the science, and had sufficient acuteness to detect the errors in the systems of others; but the task of constructing a better system in their stead required talents of a far higher order.

Wealth of Nations.

At length, in 1776, our illustrious countryman Adam Smith published the *Wealth of Nations*—a work which has done for Political Economy what the *Principia* of Newton did for Physics, and the *Esprit des Loix* of Montesquieu for Politics. In this work the science was, for the first time, treated in its fullest extent, and many of its fundamental principles placed beyond the reach of cavil and dispute. In opposition to the French economists, Dr Smith showed, that *labour* is the only source of wealth, and that the desire inherent in the breast of every individual to improve his fortune and rise in the world is the cause of its accumulation. He next traced the means by which the powers of labour may be rendered most effective, and showed that it is productive of wealth when employed in manufactures and commerce, as well as when employed in the cultivation of the land. Having established these principles, Dr Smith showed, in opposition to the commonly received opinions of the merchants, politicians, and statesmen of his time, that wealth did not consist in the abundance of gold and silver, but in the abundance of the various necessaries, conveniencies, and enjoyments of human life; he showed that individuals are always the best judges of what is for their own interest, and that, in prosecuting branches of industry advantageous to themselves, they necessarily prosecute such as are advantageous to the public.* From thence Dr Smith drew his grand inference, that every regulation intended to force industry into particular channels, or to determine the species of commercial intercourse to be carried on between different parts of the same country, or between distant and independent countries, is impolitic and pernicious—injurious to the rights of individuals—and adverse to the progress of *real* opulence and lasting prosperity.

The fact that traces of most of these principles, and even that the distinct statement of many of those that are most important, may be found in the works of previous writers, does not in the least detract from the real merits of Dr Smith. In adopting the discoveries of others, he has made them his own; he has demonstrated the truth of principles on which his predecessors had, in most cases, stumbled by chance; has disentangled and separated them from the errors by which they were incumbered; has traced their remote consequences, and pointed out their limitations; has shown their practical importance and real value—their mutual dependence and relation; and has reduced them into a consistent, harmonious, and magnificent system. We do not mean to say that Dr Smith has produced a perfect work. Undoubtedly there are errors, and those, too, of no slight importance, in the *Wealth of Nations*. The principles to which we have just referred, and which form the basis of the work, are unimpeachable; but Dr Smith has not always reasoned correctly from them, and he has occasionally introduced others, which a more careful observation and analysis has shown to be ill-founded. But, after every allowance has been made for these defects, enough still remains to justify us in considering Dr Smith as the real founder of the science. If he has not left us a perfect work, he has, at all events, left us one which contains a greater mass of useful and universally interesting truths than has ever been given to the world by any other individual; and he has pointed out and smoothed the route, by following which, subsequent philosophers have been enabled to perfect much that he had left incomplete, to rectify the mistakes into which he had fallen, and to make many new and important discoveries. Whether, indeed, we refer to the soundness of its leading doctrines, to the liberality and universal applicability of its practical conclusions, or to the powerful and beneficial influence it has had on the progress and perfection of economical science, and still more on the policy and destiny of nations, Dr Smith's work must be placed in the foremost rank of those that have done most to liberalise, enlighten, and enrich mankind.

Distinction between Politics and Political Economy.

The practical part of the science of Political Economy was long confounded with that of Politics; and it is undoubtedly true that they are very intimately connected, and that it is frequently impossible to treat those questions which strictly belong to the one without referring more or less to the principles and conclusions of the other. But, in their leading features, they are sufficiently distinct. The laws which regulate the production and distribution of wealth are the same in every country and stage of society. Those circumstances which are favourable or unfavourable to the increase of riches and population in a republic may equally exist, and will have

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che fa arrichire chi ha intrapresa la fabbrica e chi vi s'impiega con felice talento.—*Meditazioni sulla Economia Politica*, § 3.

* It is of importance to observe, that Dr Smith does not say, that, in prosecuting such branches of industry as are *most advantageous* to themselves, individuals necessarily prosecute such as are at the same time *MOST advantageous to the public*. His leaning to the system of the Economists—a leaning perceptible in every part of his work—made him so far swerve from the principles of his own system, as to admit, that individual advantage was not always a *true test* of the public advantageousness of different employments. He considered agriculture, though not the only productive employment, the *most productive* of any. He also considered the home trade as more productive than a direct foreign trade, and the latter than the carrying trade. We shall hereafter show, that there is no foundation for these distinctions.

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exactly the same effects, in a monarchy. That security of property, without which there can be no steady and continued exertion—that freedom of engaging in every different branch of industry, so necessary to call the various powers and resources of human talent and ingenuity into action—and that economy in the public expenditure, so conducive to the accumulation of national wealth—are not the exclusive attributes of any particular species of government. If free states generally make the most rapid advances in wealth and population, it is an indirect rather than a direct consequence of their political constitution. It results more from the greater *certainty* which a popular government presents that the right of property will be held sacred—that the freedom of industry will be less fettered and restricted,—and that the public income will be more judiciously levied and expended, than from the circumstance of a greater proportion of the people being permitted to exercise political rights and privileges. Give the same securities to the subjects of an absolute monarch, and they will make the same advances. Industry does not require to be stimulated by extrinsic advantages. The additional comforts and enjoyments which it procures have always been found sufficient to ensure the more persevering and successful exertions. And whatever may have been the form of government, those countries have always advanced in the career of improvement, in which the public burdens have been moderate, the freedom of industry permitted, and every individual enabled peaceably to enjoy the fruits of his labour. It is not, therefore, so much on its political organization, as on the talents and *spirit* of its rulers, that the wealth of a country is principally dependent. Economy, moderation, and intelligence on the part of those in power, have frequently elevated absolute monarchies to a very high degree of opulence and of prosperity; while, on the other hand, all the advantages derived from a more liberal system of government have not been able to preserve free states from being impoverished and exhausted by the extravagance, intolerance, and short-sighted policy of their rulers.

The sciences of Politics and of Political Economy are, therefore, sufficiently distinct. The politician examines the principles on which all government is founded, he endeavours to determine in whose hands the supreme authority may be most advantageously placed,—and unfolds the reciprocal duties and obligations of the governing and governed portions of society. The political economist does not take so high a flight. It is not of the constitution of the government, but of its ACTS only, that he presumes to judge. Whatever measures affect the production or distribution of wealth, necessarily come within the scope of his observation, and are canvassed by him. He examines whether they are in unison with the just principles of economical science. If they *are*, he pronounces them to be advantageous, and shows the nature and extent of the benefits of which they will be productive; if they *are not*, he shows in what respect they are defective, and to what extent their operation will be injurious. But he does this without inquiring into the constitution of the government by which these measures have been adopted. The circumstance of their having emanated from the privy council of an arbitrary monarch, or the representative assembly of a free state, though in other respects of supreme importance, cannot affect the immutable principles by which the economist is to form his opinion upon them.

Distinction between Statistics and Political Economy.

Besides being confounded with politics, the practical part of Political Economy has frequently been confounded with Statistics; but they are still more easily separated and distinguished. The object of the statistician is to describe the condition of a particular country at a particular period; while the object of the political economist is to discover the causes which have brought it into that condition, and the means by which its wealth and riches may be indefinitely increased. He is to the statistician what the physical astronomer is to the mere observer. He takes the facts furnished by the researches of the statistician, and after comparing them with those furnished by historians and travellers, he applies himself to discover their relation. By a patient induction—by carefully observing the circumstances attending the operation of particular principles, he discovers the effects of which they are really productive, and how far they are liable to be modified by the operation of other principles. It is thus that the relation between rent and profit—between profit and wages, and the various general laws which regulate and connect the apparently clashing, but really harmonious interests of every different order in society, have been discovered and established with all the certainty of demonstrative evidence.

PART II.—PRODUCTION OF WEALTH.

SECT. I.—*Definition of Production—Labour the only Source of Wealth.*

Definition of Production.

All the operations of nature and of art are reducible to, and really consist of *transmutations*,—of changes of form and of place. By production, in the science of Political Economy, we are not to understand the production of matter, for that is exclusively the attribute of Omnipotence, but the production of *utility*, and consequently of exchangeable value, by appropriating and modifying matter already in existence, so as to fit it to satisfy our wants, and to contribute to our enjoyments. The labour which is thus employed is the only source of wealth.* Na-

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* This point has been strongly and ably stated by M. Destutt Tracy—" Non-seulement," says he, " nous ne créons jamais rien, mais il nous est même impossible de concevoir ce que c'est que *créer* ou *anneantir*, si nous entendons rigoureusement par ces mots, *faire quelque chose de rien*, ou *reduire quelque chose à rien*; car nous n'avons jamais vu un étre quelconque sortir du néant ni y rentrer. De là cet axiome admis par toute l'antiquite: rien ne vient de *rien*, et ne peut redevenir *rien*. Que faisons-nous donc par notre travail, *par notre action sur tous les etres qui nous entourent?* Jamais rien, qu'opérer dans ces etres des changements

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ture spontaneously furnishes the matter of which commodities are made; but, independently of labour, matter is rarely of any use whatever, and is never of any value. Place us on the banks of a river, or in an orchard, and we shall infallibly perish, either of thirst or hunger, if we do not, *by an effort of industry*, raise the water to our lips, or pluck the fruit from its parent tree. It is seldom, however, that the mere appropriation of matter is sufficient. In the infinite majority of cases, labour is required not only to appropriate it, but also to convey it from place to place, and to give it that peculiar figure and shape, without which it may be totally useless, and incapable of either ministering to our necessities or our comforts. The coal used in our fires is buried deep in the bowels of the earth, and is absolutely worthless until the labour of the miner has extracted it from the mine, and brought it into a situation where it can be made use of. The stones and mortar of which our houses are built, and the rugged and shapeless materials from which the various articles of convenience and ornament with which they are furnished have been prepared, were, in their original state, alike destitute of value and utility. And of the innumerable variety of animal, vegetable, and mineral products which form the materials of our food and clothes, none were originally serviceable, and many were extremely noxious to man. It is his *labour* that has given them utility, that has subdued their bad qualities, and made them satisfy his wants, and minister to his comforts and enjoyments. "Labour was the first price, the original purchase money that was paid for all things. It was not by gold or by silver, but by labour, that all the wealth of the world was originally purchased."—(*Wealth of Nations*, Vol. I. p. 44. 8vo edit.)

If we observe the progress, and trace the history of the human race in different countries and states of society, we shall find their comfort and happiness to have been always nearly proportioned to the power which they possessed of rendering their labour effective in appropriating the raw products of nature, and in fitting and adapting matter to their use. The savage, whose labour is confined to the gathering of wild fruits, or to the picking up of the shell fish on the sea coast, is placed at the very bottom of the scale of civilization, and is, in point of comfort, decidedly inferior to many of the lower animals. The *first* step in the progress of society is made when man learns to hunt wild animals, to feed himself with their flesh, and to clothe himself with their skins. But labour, when confined to the chace, is extremely barren and unproductive. Tribes of hunters, like beasts of prey, whom they are justly said to resemble closely in their habits and modes of subsistence, are but thinly scattered over the surface of the country which they occupy; and notwithstanding the fewness of their numbers, any unusual deficiency in the supply of game never fails to reduce them to the extremity of want. The *second* step in the progress of society is made when the tribes of hunters and fishers apply their labour, like the ancient Scythians and modern Tartars, to the domestication of wild animals and the rearing of flocks. Their subsistence is much less precarious than that of hunters, but they are almost entirely destitute of all those comforts and elegancies which give to civilized life its chief value. The *third* and most decisive step in the progress of civilization—in the great art of producing the necessaries and conveniences of life—is made when the wandering tribes of hunters and shepherds renounce their migratory habits, and become agriculturists and manufacturers. It is then, properly speaking, that man, shaking off that indolence which is natural to him, begins fully to avail himself of the productive powers of industry. He then becomes laborious, and, by a necessary consequence, his wants are then, for the first time, fully supplied, and he acquires an extensive command over the articles necessary to his comfort as well as his subsistence.

The Earth not a Source of Wealth.

However paradoxical the assertion may at first sight appear, it is, notwithstanding, unquestionably true that the earth does not gratuitously supply us with a single atom of wealth. It is a powerful machine given by Providence to man; but without labour this machine would be altogether useless, and would for ever stand idle and unemployed. It is to labour that the products of the earth owe their *value*, and it is by its intervention that they become useful. The surface of the earth is, in its natural state, covered with fruits and game; its bowels contain an infinite variety of mineral products; its seas and rivers are stored with fish, and it is endowed with inexhaustible vegetative and productive powers; but all these powers and products are plainly of no use whatever, and have no value, until the labour of man has called the former into action, and appropriated the latter, and given them that peculiar form which is required to fit them to support his existence, or to increase his enjoyments.

Opinion of Hobbes.

The importance of labour in the production of wealth was very clearly perceived both by Hobbes and Locke. At the commencement of the 24th chapter (entitled, "Of the *Nutrition and Procreation of a Commonwealth*") of the *Leviathan*, published in 1651, Hobbes says, "The *nutrition* of a commonwealth consisteth in the *plenty* and *distribution* of *materials* conducing to life.

"As for the plenty of matter, it is a thing limited by nature to those commodities which, from (the two breasts of our common mother) *land* and *sea*, God usually either freely giveth, or for labour selleth to mankind.

"For the matter of this nutriment, consisting in animals, vegetables, minerals, God hath freely laid

de forme on de lieu qui les approprient à notre usage, qui les rendent utiles à la satisfaction de nos besoins. Voila ce que nous devons entendre par *produire; c'est donner aux choses une utilité qu'elles n'avoient pas*. Quel que soit notre travail, s'il n'en resulte point d'utilité, il est infructeux; s'il en resulte, il est *productif*."—(*Elemens d'Ideologie*, Tome III. p. 162.)

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them before us, in or near to the face of the earth; so as there needeth no more but the labour and industry of receiving them. Insomuch that *plenty dependeth* (next to God's favour) *on the labour and industry of man.*"

Opinion of Locke.

But Mr Locke had a much clearer apprehension of this doctrine. In his *Essay on Civil Government*, published in 1689, he has entered into a lengthened, discriminating, and able analysis to show that it is from labour that the products of the earth derive almost all their value. "Let any one consider," says he, "what the difference is between an acre of land planted with tobacco or sugar, sown with wheat or barley, and an acre of the same land lying in common, without any husbandry upon it, and he will find that the improvement of labour makes the far greater part of the value. I think it will be but a very modest computation to say, that of the products of the earth useful to the life of man, *nine-tenths* are the effects of labour; nay, if we will rightly consider things as they come to our use, and cast up the several expences about them, what in them is purely owing to nature, and what to labour, we shall find, that in most of them *ninety-nine hundredths* are wholly to be put on the account of labour.

"There cannot be a clearer demonstration of any thing, than several nations of the Americans are of this, who are rich in land, and poor in all the comforts of life; whom nature having furnished as liberally as any other people with the materials of plenty; *i. e.* a fruitful soil apt to produce in abundance what might serve for food, raiment, and delight; yet for *want of improving it by labour*, have not one hundredth part of the conveniencies we enjoy; and the king of a large and fruitful territory there feeds, lodges, and is worse clad than a day-labourer in England.

"To make this a little clear, let us but trace some of the ordinary provisions of life through their several progresses, before they come to our use, and see how much of their value they receive from human industry. Bread, wine, and cloth, are things of daily use, and great plenty; yet, notwithstanding, acorns, water, and leaves, or skins, must be our bread, drink, and clothing, did not labour furnish us with these more useful commodities; for whatever bread is more worth than acorns, wine than water, and cloth or silk than leaves, skins, or moss, that is solely owing to labour and industry; the one of these being the food and raiment which unassisted nature furnishes us with; the other provisions which our industry and pains prepare for us; which how much they exceed the other in value, when any one hath computed, he will then see how much labour makes the far greatest part of the value of things we enjoy in this world; and the ground which produces the materials is scarce to be reckoned on as any, or, at most, but a very small part of it.

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"An acre of land that bears here twenty bushels of wheat, and another in America, which, with the same husbandry, would do the like, are, without doubt, of the same natural intrinsic value. But yet, the benefit mankind receives from the one in a year is worth L. 5, and from the other possibly not worth *one penny*; if all the profit an Indian received from it were to be valued and sold here, at least, I may truly say, not $\frac{1}{1000}$.—'Tis labour, then, which puts the greatest part of value upon land, *without which it would scarcely be worth any thing*: 'Tis to that we owe the greatest part of its useful products; for all that the straw, bran, bread of that acre of wheat, is more worth than the product of an acre of good land, which lies waste, is all the effect of labour. For 'tis not merely the ploughman's pains, the reaper's and thrasher's toil, and the baker's sweat, is to be counted into the bread we eat, the labour of those who broke the oxen, who digged and wrought the iron and stones, who fitted and framed the timber employed about the plough, mill, oven, or any other utensils, which are a vast number, requisite to this corn, from its being seed to be sown, to its being made bread, must all be charged on the account of *labour*, and received as an effect of that. Nature and the earth furnishing only the almost worthless materials as in themselves.—'Twould be a strange *catalogue of things that industry provided and made use of about every loaf of bread*, before it came to our use, if we could trace them. Iron, wood, leather, barks, timber, stone, brick, coals, lime, cloth, dyeing-drugs, pitch, tar, masts, ropes, and all the materials made use of in the ship that brought away the commodities made use of by any of the workmen, to any part of the work; all which, it would be almost impossible, at least too long to reckon up." (*Of Civil Government*, Book II. § 40, 41, 42, and 43.) *

Had Mr Locke carried his analysis a little further, he could not have failed to perceive that neither water, leaves, skins, nor any of the spontaneous productions of nature, have any *value*, except what they owe to the labour required to appropriate them. The value of water to a man placed on the bank of a river depends on the labour necessary to raise it from the river to his lips; and its value, when carried ten or twenty miles off, is equally dependent on the labour necessary to convey it there. All the rude products, and all the productive powers and

* This is a very remarkable passage. It contains a far more distinct and comprehensive statement of the fundamental doctrine, that labour is the constituent principle of value, than is to be found in any other writer previous to Dr Smith, or than is to be found even in the *Wealth of Nations*. But Mr Locke does seem to have been sufficiently aware of the real value of the principle he had elucidated, and has not deduced from it any important practical conclusion. On the contrary, in his tract on the *Raising of the Value of Money*, published in 1691, he lays it down broadly that all taxes, howsoever imposed, must ultimately *fall on the land;* whereas, it is plain he ought, consistently with the above principle, to have shown that they would fall, not exclusively on the produce of land, but generally on the *produce of industry*, or on all species of commodities.

Labour the only Source of Wealth.

capacities of nature, are gratuitously offered to man. Nature is not niggardly or parsimonious. She neither demands nor receives an equivalent for her favours. An object which it does not require any portion of labour to appropriate or to adapt to our use, may be of the very highest utility; but, as it is the free gift of nature, it is utterly impossible it can be possessed of the smallest value. *

"Si je retranche," to use a striking illustration of this doctrine given by M. Canard, "de ma montre, par la pensée, tous les travaux qui lui ont été successivement appliquées, il ne resterai que quelques grains de minéral placées dans l'interieur de la terre d'ou on les a tirés, et ou ils n'ont aucune valeur. De même si je decompose le pain que je mange, et que j'en retranche successivement tous les travaux successifs qu'il a reçus, il ne restera que quelques tiges d'herbes, graminées, eparses dans des deserts incultes, et sans aucune valeur." (*Principes d'Economie Politique*, p. 6.)

It is to labour, therefore, and to labour only, that man owes every thing possessed of exchangeable value. Labour is the talisman that has raised him from the condition of the savage—that has changed the desert and the forest into cultivated fields—that has covered the earth with cities and the ocean with ships—that has given us plenty, comfort, and elegance, instead of want, misery, and barbarism.

Having established this fundamental principle—having shown that it is labour only that gives exchangeable value to commodities—it is plain the great practical problem of the science of Political Economy must resolve itself into a discussion of the means whereby labour may be rendered most efficient, or whereby *the greatest amount of necessary, useful, and agreeable products may be obtained with the least quantity of labour.* Wealth, as we have already shown, is always increased with every diminution of the labour required to produce the articles of which it consists. Every measure and invention that has any tendency to save labour, or to reduce the cost of producing commodities, must add proportionably to our power of obtaining wealth and riches, while every measure or regulation that has any tendency to waste labour, or to raise the cost of producing commodities, must equally lessen this power. This is the simple and decisive test by which we are to judge of the expediency of every measure affecting the wealth of the country, and of the value of every invention. If they render labour more productive—if they have a tendency to reduce the exchangeable value of commodities, to render them more easily obtainable, and to bring them within the command of a greater portion of society, they must be advantageous; but if their tendency be different, they must as certainly be disadvantageous. Considered in this point of view, that great branch of the science of Political Economy which treats of the production of wealth, will be found to be abundantly simple, and easily understood.

Labour, according as it is applied to the raising of raw produce—to the fashioning of that raw produce, when raised, into articles of utility, convenience, or ornament—and to the conveyance of raw and wrought produce from one country and place to another—is said to be agricultural, manufacturing, or commercial. An acquaintance with the particular processes, and most advantageous methods, of applying labour in each of these grand departments of industry, forms the peculiar and appropriate study of the agriculturist, manufacturer, and merchant. It is not consistent with the object of the political economist to enter into the details of particular businesses and professions. He confines himself to an investigation of the means by which labour in general may be rendered most productive, and how its powers may be increased in *all* the departments of industry.

Sect. II.—*Means by which the Productive Powers of Labour are increased—Security of Property—Division of Labour—Accumulation and Employment of Capital.*

Means by which the Productive Powers of Labour may be increased.

The most careless and inattentive observer of the progress of mankind from poverty to affluence must have early perceived, that there are *three* circumstances whose conjoint operation is necessary to stimulate and improve the productive powers of industry, and in the absence of which men could never have emerged from barbarism. The *first*, and most indispensable, is the *security of property*, or a well-founded conviction in the mind of every individual that he will be allowed to dispose at pleasure of the

* Bishop Berkeley entertained very just opinions respecting the source of wealth. In his *Querist*, published in 1735, he asks,—"Whether it were not wrong to suppose *land* itself to be wealth? And whether the *industry of the people* is not first to be considered, as that which constitutes wealth, which makes even land and silver to be wealth, neither of which would have any value, but as means and motives to industry?

"Whether, in the wastes of America, a man might not possess twenty miles square of land, and yet want his dinner, or a coat to his back."—*Querist*, Numbers 38 and 39.

We shall afterwards notice Sir William Petty's opinion on this subject.

M. Say appears to think (*Discours Preliminaire*, p. 37) that Galiani was the *first* who showed, in his treatise *Della Moneta*, published in 1750, that labour was the only source of wealth. But the passages we have now laid before the reader prove the erroneousness of this opinion. Galiani has entered into *no analysis or argument to prove the correctness of his statement*; and, as it appears from other parts of his work, that he was well acquainted with Mr Locke's *Tracts on Money*, a suspicion naturally arises that he had seen the *Essay on Civil Government*, and that he was really indebted to it for a knowledge of this principle. This suspicion derives strength from the circumstance of Galiani being still less aware than Mr Locke of the value of the discovery.—See *Trattato Della Moneta*, p. 39, ediz. 1780.

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fruits of his labour. The *second* is the introduction of exchange or barter, and the consequent appropriation of particular individuals to particular employments. And the *third* is the accumulation and employment of the produce of previous labour, or, as it is more commonly termed, of capital, or stock. All the improvements that have ever been made, or that ever can be made, in the great art of producing the necessaries, comforts, and conveniencies of human life, are *all* resolvable into the more judicious and successful application of one or more of those means of stimulating labour, and adding to its power. To give a full exposition of the nature and influence of each would far exceed the limits of this article; and we must content ourselves with such observations as may suffice to give a general idea of their operation.

Security of Property.

Security of Property.—Security of property is the first and most indispensable requisite to the production of wealth. Its utility in this respect is, indeed, so obvious and striking, that it has been more or less respected in every country, and in the earliest and rudest periods of society. All have been impressed with the reasonableness of the maxim which teaches that those who *sow* ought to be permitted to *reap*—that the *labour* of a man's body and the *work* of his hands are to be considered as exclusively his own. No savage horde has ever been discovered in which the principle of *meum* and *tuum* was not recognised. Nothing, it is plain, could ever tempt any one to engage in any laborious employment—he would neither domesticate wild animals, nor clear and cultivate the ground, if, after months and years of toil, when his flocks had become numerous, and his harvests were ripening for the sickle, a stranger were to be allowed to rob him of the produce of his industry. No wonder, therefore, that the utility of some general regulations, which should secure to every individual the peaceable enjoyment of the produce he had raised, and of the ground he had cultivated and improved, suggested itself to the first legislators. The author of the book of *Job* places those who removed their neighbour's land-marks at the head of his list of wicked men; and some of the earliest profane legislators subjected those who were guilty of this offence to a capital punishment. (Goguet, *De l'Origine des Loix, &c.* Tom. I. p. 30. 4to ed.)

Dr Paley has said that the *law of the land* is the real foundation of the right of property. But the obvious *utility* of securing to each individual the produce which has been raised by his industry, has undoubtedly formed the irresistible reason which has induced every people emerging from barbarism to establish this right. The institution of the right of property is, in truth, the foundation on which all the other institutions of society rest. Until property had been publicly guaranteed, men must have looked on each other as enemies, rather than as friends. The idle and improvident are always desirous of seizing on the earnings of the laborious and frugal; and, if they were not restrained by the strong arm of the law—if they were permitted to prosecute their attacks, they would, by generating a feeling of insecurity, effectually check both industry and accumulation, and sink all classes to the same level of hopeless misery as themselves. In truth, the security of property is even more necessary to accumulation than it is to production. No man ever did or ever will deny himself an immediate gratification when it is within his power, unless he thinks, that, by doing so, he has a fair prospect of obtaining a greater accession of comforts and enjoyments, or of avoiding a greater evil at some future period. Where the right of property is vigilantly protected, an industrious man, who produces as much by one day's labour as is sufficient to maintain him two days, does not lie idle the second day, but accumulates the surplus produce above his wants as a capital; the increased consequence and enjoyments which the possession of capital brings along with it, being, in the great majority of cases, more than sufficient to counterbalance the desire of immediate gratification. But, wherever property is insecure, we look in vain for the operation of the principle of accumulation. "It is plainly better for us," is then the invariable language of the people, "to enjoy while it is in our power, than to accumulate property which we shall not be permitted to use, and which will either expose us to the extortion of a rapacious government, or to the unrestrained depredations of those who exist only by the plunder of their more industrious neighbours."

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But the security of property is not violated merely when a man is deprived of the power of peaceably enjoying the fruits of his industry; it is also violated, and perhaps in a still more glaring and unjustifiable manner, when he is prevented from using the powers with which nature has endowed him, in any way, not injurious to others, that he considers most beneficial to himself. Of all the species of property which a man can possess, *the faculties of his mind and the powers of his body* are most particularly his own. He ought, therefore, to be permitted to enjoy, that is, to use or exert these powers at his discretion. And hence the right of property is as much, or more infringed upon, when a man is interdicted from engaging in a particular branch of business, as it is when he is forcibly bereft of the property he had produced and accumulated. Every monopoly which gives to a few individuals the exclusive power of carrying on certain branches of industry, is thus, in fact, established in direct violation of the right of property of every other individual. It prevents them from using their natural capacities or powers in the manner which they might have considered best; and, as every man who is not a slave is held, and justly held, to be the best, and, indeed, the only judge of what is advantageous for himself, the principles of natural law and the right of property are both subverted when he is excluded from any employment. In like manner, the right of property is violated whenever any regulation is made to force an individual to employ his labour or capital in a particular way. The property of a landlord is violated when he is compelled to adopt any system of cultivation, even supposing it to be really preferable to that which he was previously following. The property of the capitalist is violated when he is obliged to accept a particular rate of interest for his stock, and the property of the labourer is violated whenever he is obliged

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to betake himself, in preference, to any particular occupation.

Effects of insecurity.

The finest soil, the finest climate, and the finest intellectual powers, can prevent no people from becoming barbarous, poor, and miserable, if they have the misfortune to be subjected to a government which does not respect the right of property. This is the greatest of all calamities. The ravages of civil war, of pestilence, and of famine, may be repaired; but nothing can enable a nation to contend against the deadly influence of an established system of violence and rapine. It is the want of security—the want of any lively and well-founded expectation of being permitted freely to dispose of the fruits of their industry, that is the principal cause of the wretched state of the Ottoman dominions at the present day, as it was of the decline of industry and arts in Europe during the middle ages. When the Turkish conquerors overran those fertile and beautiful countries in which they are still permitted to encamp, they parcelled them among their followers, on condition of their performing certain military services, on a plan corresponding, in many important particulars, to the feudal system of our ancestors. But these possessions are not hereditary. They do not descend to the children or legatees of the present possessor, but, on his death, revert to the Sultan. Among the occupiers of land in Turkey there is, therefore, no thought of futurity. No one can feel any interest about the prosperity of an unknown successor; and no one ever executes any improvement of which he does not expect to be able to reap all the advantage during his own life. This is assigned by Lady Wortley Montague as the cause why the Turks are so extremely careless about their houses. They never construct them of solid or durable materials. And it would be a gratification to them to be assured that they would fall to pieces the moment after they had breathed their last. Under this miserable government the palaces have been changed into cottages, and the cities into villages. The long continued want of security has extinguished the very spirit of industry, and destroyed not only the power, but even the desire to emerge from barbarism.

Had it been possible for arbitrary power to profit by the lessons of experience, it must long since have perceived that its own wealth, as well as the wealth of its subjects, would be most effectually promoted by maintaining the inviolability of property. Were the Turkish government to establish a vigilant system of police—to secure to each individual the unrestricted power of disposing of the fruits of his labour—and to substitute a regular plan of taxation in the place of the present odious system of extortion and tyranny, industry would revive, capital and population would be augmented, and moderate duties, imposed on a few articles in general demand, would bring a much larger sum into the coffers of the treasury than all that is now obtained by force and violence. The *stated* public burdens to which the Turks are subjected are light when compared with those imposed on the English, the Hollanders, or the French. But the latter know that when they have paid the taxes due to government, they will be permitted peaceably to enjoy or to accumulate the remainder of their earnings; whereas the Turk has no security but that the next moment after he has paid his stated contribution, the Pacha, or one of his satellites, may trip him of every additional farthing he possesses! Security is the foundation—the principal element in every well digested system of finance. When maintained inviolate, it enables a country to support, without much difficulty, a very heavy load of taxes; but where there is no security—where property is a prey to rapine and spoliation—to the attacks of the needy, the powerful, or the profligate—the smallest burdens are justly regarded as oppressive, and uniformly exceed the means of the impoverished and spiritless inhabitant.

Case of the Jews.

The Jews have been supposed to afford an instance of a people, whose property has been long exposed to an almost uninterrupted series of attacks, and who have, notwithstanding, continued to be rich and industrious. But when rightly examined, it will be found that the case of the Jews forms no exception to the general rule. The absurd prejudices with which the Jews have been almost universally regarded, long prevented their acquiring any property in land, and have excluded them from participating in the benefits derived from the charitable institutions of the different countries among which they are scattered. Having, therefore, no adventitious support on which to depend, in the event of their becoming infirm or destitute, they had a powerful additional motive to save and accumulate; and being excluded from agriculture, they were of necessity compelled to addict themselves, in preference, to commerce. In an age when the profession of a merchant was generally looked upon as something mean and sordid, and when, of course, they had comparatively little competition, they must have made considerable profits; but these have been very greatly exaggerated. It was natural that those who were indebted to the Jews should represent their gains as enormous; for this inflamed the existing prejudices against them, and afforded a miserable pretext for defrauding them of their just claims. There are a few rich Jews in most of the large cities of Europe; but the majority of that race have ever been, and still are, as poor as their neighbours.

Let us not, therefore, deceive ourselves by supposing that it is possible for any nation or any people to emerge from barbarism, or to become wealthy, populous, and civilized, without the security of property. From whatever point of the political compass we may set out, this is the principle to which we must come at last. Security is indispensably necessary to the successful exertion of the powers of industry. Where it is wanting, it is idle to expect either riches or civilization.*

Objections of Rousseau and Beccaria ill-founded.

Rousseau and some other sentimental writers

* "Ce n'est que la ou les proprietès sont assurés, ou l'emploi des capitaux est abandonné au choix de

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have made an objection to the institution of the right of property, which has been, in some measure, sanctioned by the authority of the Marquis Beccaria.* They allow that the security of property is advantageous for those who possess it; but they contend, that it is disadvantageous for those who are poor and destitute. It has condemned, they affirm, the greater portion of mankind to a state of misery, and has provided for the exaltation of the few by the depression of the many! The sophistry of this reasoning is so apparent, as hardly to require to be pointed out. The right of property has not made *poverty*, but it has made *wealth*. Previous to the institution of this right, those nations which are now most civilized, were sunk to the same level of wretchedness and misery as the savages of New Holland and Kamtschatska. All classes have been benefited by this change; and it is mere error and delusion to suppose that the rich have been benefited at the expence of the poor. The institution of the right of property gives no advantage to any one man over any other man. It deals out justice impartially to all. It does not say, labour, and I will reward you; but it says, "*labour, and I shall take care that none shall be permitted to rob you of the produce of your exertions.*" The institution of the right of property has not made all men rich, because it could not make all men frugal and industrious. But it has done more than all the other institutions of society put together to produce this effect. It is not, as it has been sometimes ignorantly or knavishly represented, a bulwark thrown up to protect and secure the property of a few favourites of fortune. It is a rampart raised by society against its common enemies—against rapine and violence, plunder and oppression. Without its protection, the rich man would become poor, and the poor man would never be able to become rich—all would sink to the same bottomless abyss of barbarism and poverty. "It is the security of property," to use the just and forcible expressions of a profound writer, "that has overcome the natural aversion of man to labour, that has given him the empire of the earth, that has given him a fixed and permanent residence, that has implanted in his breast the love of his country and of posterity. To enjoy immediately—to enjoy without labour, is the natural inclination of every man. This inclination must be restrained; for its obvious tendency is to arm all those who have nothing against those who have something. The law which restrains this inclination, and which secures to the humblest individual the quiet enjoyment of the fruits of his industry, is the most splendid achievement of legislative wisdom—the noblest triumph of which humanity has to boast."—(Bentham, *Traité de Legislation*, Tome II. p. 37.)

Division of Labour.

Division of Labour.—The division of labour naturally divides itself into two separate branches;—1*st*, The division of labour among individuals; and 2*d*, Its division among nations.

1. *Individual Division of Labour.*—The division of labour can only be imperfectly introduced in rude societies, and thinly peopled countries. But in every state of society—in the rudest, as well as in the most improved—we can trace the operation and effects of this principle. The various physical powers, talents, and propensities with which men are endowed, naturally fit them for different occupations; and a regard to mutual interest and convenience necessarily leads them, at a very early period, to establish a system of barter and a separation of employments. Each individual finds that he can obtain a greater quantity of all sorts of commodities by devoting himself to some particular business, and exchanging his surplus produce for such parts of the produce of other people's labour as he may have occasion for and they may be disposed to part with, than if he had attempted directly to produce all the articles which he consumes. As society advances, this division becomes more and more extended. In process of time, one man becomes a tanner, or dresser of skins; another, a shoemaker; a third, a weaver; a fourth, a house-carpenter; a fifth, a smith, and so on. Each endeavours to cultivate and bring to perfection whatever talent or genius he may possess for the species of industry in which he is employed. The national wealth and the comforts of all classes are, in consequence, prodigiously augmented. In a country where the division of labour has been carried to a considerable extent, agriculturists are not obliged to spend their time in clumsy attempts to manufacture their own produce; and manufacturers cease to interest themselves about the raising of corn and the fattening of cattle. The facility of exchanging is the vivifying principle of industry. It stimulates agriculturists to adopt the best system of cultivation and to raise the largest crops, because it enables them to exchange whatever portion of the produce of their lands exceeds their own wants for other commodities conducing to their comforts and enjoyments; and it equally stimulates manufacturers and merchants to increase the quantity and to improve the quality of their goods, that they may

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ceux qui les possedent; ce n'est que la dis-je, que les particuliers seront encouragés à se soumettre aux privations les plus dures pour compenser par leurs épargnes les retards que la profusion du gouvernement peut apporter aux progrés de la richesse national. Si l'Angleterre, malgrè ses guerres ruineuses, est parvenue à un haut degrè d'opulence; si malgrè les contributions enormes dont le peuple y est chargè, son capital est pourtant accrue dans le silence par l'economie des particuliers, il ne faut attribuer ces èffets qu'a là libertè des personnes et à la suretè des proprietès qui y regnent, plus que dans acun autre pays de l'Europe, la Suisse exceptè." (Storch, *Traité d'Economie Politique*, Tom. I. p. 317.)

* Speaking of theft, Beccaria calls it, "Il delitto di quella infelice parte di uomini, a cui *il diritto di proprietà (terribile, e forse non necessario diritto), non ha lasciato, che una nuda essistenza."—Dei Delitti e delle Pene*, § 22.

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thereby be enabled to obtain a greater supply of raw produce. A spirit of industry is thus universally diffused; and that apathy and languor, which is characteristic of a rude state of society, entirely disappear.

But it is not the mere facility of exchanging, or the circumstance of being able to barter the surplus produce of one's own labour for such parts of the surplus produce of other people's labour, as we may be desirous of obtaining and they may choose to part with, that renders the separation of employments of such signal advantage. The introduction of barter and the division of labour not only enables each individual to betake himself in preference to those departments which suit his taste and disposition, but it makes a positive and a large addition to the efficacy of his powers, and enables him to produce a much greater quantity of commodities than he could have done had he engaged indiscriminately in different employments. Dr Smith, who has treated this subject in the most masterly manner, has classed the circumstances which conspire to increase the productive powers of industry, when labour is divided, under the following heads:—*First*, To the increase of the skill and dexterity of every particular workman; *second*, to the saving of time, which is commonly lost in passing from one particular employment to another; and, *third*, to the circumstance of the division of employments having a tendency to facilitate the invention of machines and of processes for abridging and saving labour. We shall make a few observations on each of these heads.

Division of Labour increases the Skill and Dexterity of the Workman:

1*st*, *Respecting the improvement of the skill and dexterity of the labourer*, it is sufficiently plain that when a person's whole attention is devoted to one branch of business, when all the energies of his mind and the powers of his body are made to converge, as it were, to a single point, he must attain to a degree of proficiency in that particular branch, to which no individual engaged in a variety of occupations can be expected to reach. A peculiar play of the muscles, or *sleight of hand*, is necessary to perform the simplest operation in the best and most expeditious manner; and this can only be acquired by habitual and constant practice. Dr Smith has given a striking example, in the case of the nail manufacturer, of the extreme difference between training a workman to the precise occupation in which he is to be employed, and training him to a similar and closely allied occupation. "A common smith," says he, "who, though accustomed to handle the hammer, has never been used to make nails, if, upon some particular occasion, he is obliged to attempt it, will scarce, I am assured, be able to make above two or three hundred nails in a day, and those very bad ones. A smith who has been accustomed to make nails, but whose sole or principal business has not been that of a nailer, can seldom, with his utmost diligence, make more than eight hundred or a thousand nails in a day. But I have seen several boys under twenty years of age, who had never exercised any other trade but that of making nails, who, when they exerted themselves, could make, each of them, upwards of *two thousand three hundred nails in a day*;" or nearly three times the number of the smith who had been accustomed to make them, but who was not entirely devoted to that particular business!

Saves Time.

2*d*, The effect of the division of labour in preventing that *waste of time in moving from one employment to another*, which must always take place when an individual is engaged in different occupations, is even more obvious than the advantage derived from the improvement of the skill and dexterity of the labourer. When the same individual carries on different employments, in different and perhaps distant places, and with different sets of tools, it is plainly impossible he can avoid losing a considerable portion of time in passing between them. If the different businesses in which a labourer is to be engaged could be carried on in the same workshop, the loss of time would be less, but even in that case it would be considerable. "A man," as Dr Smith has justly observed, "commonly saunters a little in changing from one business to another. When he first begins his work, he is seldom keen or hearty; his mind is said not to go along with it, and for some time he rather trifles than applies himself in good earnest. The habit of sauntering and of indolent and careless application, which is naturally, or rather necessarily acquired by every country workman, who is obliged to change his work and his tools every half hour, and to apply his hand in working different ways almost every day of his life, renders him almost always slothful and lazy, and incapable of any rigorous application, even on the most pressing occasion. Independent, therefore, of his deficiency in point of dexterity, this cause alone must always reduce considerably the quantity of work which he is capable of performing."—(*Wealth of Nations*, I. p. 14.)

Facilitates the Invention of Machines:

3*d*, With regard to the effect of the division of employments in *facilitating the invention of machines, and processes for abridging and saving labour*, it is obvious that those engaged in any branch of industry must be more likely to discover easier and readier methods for carrying it on, when the whole attention of their minds is devoted exclusively to it, than if it were dissipated among a variety of objects. But it is a mistake to suppose, as has been sometimes done, that it is only the inventive genius of workmen and artificers that is whetted and improved by the division of labour. As society advances, the study of particular branches of science and of philosophy becomes the principal or sole occupation of the most ingenious men. Chemistry becomes a distinct science from natural philosophy; the physical astronomer separates himself from the astronomical observer, the political economist from the politician, and each meditating exclusively, or principally, on his peculiar department of science, attains to a degree of proficiency and expertness in it to which the general scholar seldom or never reaches. And hence, in labouring to promote our own ends, we all necessarily adopt that precise course which is most advantageous to all. Like the different parts of a well constructed engine, the inhabitants of a civilized country are all mutually dependent on, and connected with, each other. Without any previous concert, and obeying only the powerful and steady impulse of self-interest, they universally conspire to the same great end, and

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contribute each in their respective sphere to furnish the greatest possible supply of necessaries, luxuries, conveniencies, and enjoyments.

Division of Labour Limited by the Extent of the Market.

But it is necessary to observe, that the advantages derived from the division of labour, though they may be, and in fact are, partially enjoyed in every country and state of society, can only be carried to their full extent, where there is a great power of exchanging, or an *extensive market*. There are an infinite variety of employments which cannot be separately carried on out of the precincts of a large city; and, in all cases, the division becomes just so much the more perfect, according as the demand for the produce of the workmen is extended. It is stated by Dr Smith that ten labourers employed in different departments in a pin manufactory can produce 48,000 pins a day; but it is evident that if the demand was not sufficiently extensive to take off this quantity, it would be impossible to carry the division so far. The same principle holds good in every case. A cotton mill could not be constructed in a small country which had no intercourse with its neighbours. The demand and competition of Europe and America has been necessary to carry the manufactures of Glasgow, Manchester, and Birmingham, to their present state of improvement.

The effects of the division of labour in increasing the quantity and perfection of the products of industry have been noticed by several of the writers who preceded Dr Smith, and especially by Mr Harris and M. Turgot. But neither of these writers have done what Dr Smith did. None of them have fully analysed and exhibited its various effects; and none of them have shown that the power of engaging in different employments depended on the *power of exchanging*; and that, consequently, the advantages derived from the division of labour were necessarily dependent on, and regulated by, the extent of the market. This is a principle of very great importance, and by establishing it Dr Smith shed a new light on the whole science, and laid the foundation of many important practical conclusions. "Présentée de cette maniere," says M. Storch, "l'idée de la division du travail étoit absolument neuve; et l'effet qu'elle a fait sur les contemporains de Smith, prouve bien qu'elle l'etoit réellement pour eux. Telle qu'elle se trouve indiquée dans les passages que je viens de citer, elle n'a fait aucune impression. Developpée par Smith, cette idée a d'abord saisi tous ses lecteurs; tous en ont senti la verité et l'importance; et cela suffit pour lui en assurer tout l'honneur, lors même que son genie aît été guidé par les indications de ses devanciers."—(Tome VI. p. 10.)

Territorial Division of Labour.

2. *Territorial Division of Labour, or Commerce.*—Besides that sort of division of labour which enables each individual in a limited society to confine himself to a particular employment, there is another and most important branch of the division of labour, which not only enables particular individuals, but the inhabitants of entire districts, and even nations, to addict themselves in preference to certain branches of industry. It is on this *territorial division of labour*, if we may so term it, that the commerce which is carried on between different districts of the same country, and between different countries, is founded. The various soils, climates, and capacities of production, of different districts of an extensive country, fit them for being appropriated in preference to certain species of industry. A district where coal is abundant, which has an easy access to the ocean, and a considerable command of internal navigation, is the natural seat of manufactures. Wheat and other species of grain are the proper products of rich arable soils; and cattle, after being reared in mountainous districts, are most advantageously fattened in meadow and low grounds. Nothing is more obvious than that the inhabitants of these different districts, by separately confining themselves to the particular branches of industry for the successful prosecution of which they have some peculiar *natural capability*, must produce an infinitely greater quantity of useful and agreeable commodities than they could do were they to devote their labour indiscriminately to every different employment. It is impossible to doubt that vastly more manufactured goods, more corn, and more cattle, are produced by the inhabitants of Glasgow, of the Carse of Gowrie, and of Argyleshire, respectively confining themselves to manufactures, agriculture, and the rearing of cattle, than if each endeavoured directly to supply themselves with all these various products, without the intervention of an exchange.

But it is easy to see that foreign trade, or the territorial division of labour between different and independent countries, will contribute to increase the wealth of each in precisely the same manner that the trade between different provinces of the same kingdom contributes to increase their wealth. There is a still greater difference between the productive powers wherewith nature has endowed different and distant countries than there is between the productive powers of the provinces of the same country. The establishment of a free intercourse between them must, therefore, be proportionably advantageous. It would evidently cost an infinitely greater expence to raise the wines of France or Spain in England than it would do to make Yorkshire yield the same products as Devonshire. Indeed, there are a multitude of products, and some of them of the very greatest utility, which cannot possibly be raised except in particular situations. Were it not for commercial intercourse, we should not be able to obtain the smallest supply of tea, sugar, raw cotton, raw silk, gold bullion, and a thousand other equally useful and valuable commodities. Providence, by giving different soils, climates, and natural productions, to different countries, has evidently provided for their mutual intercourse and civilization. By permitting the people of each to employ their capital and labour in those departments in which their geographical situation, the physical capacities of their soil, their national character and habits fit them to excel, foreign commerce has a wonderful effect in multiplying the productions of art and industry. When the freedom of commerce is not restricted, each country necessarily devotes itself to such employments as are most beneficial to each. This pursuit of individual advantage is admirably connected with the good of the whole. By stimulating industry, by rewarding ingenuity, and

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by using most efficaciously the particular powers bestowed by nature, commerce distributes labour most effectively and most economically; while, by increasing the general mass of necessary and useful products, it diffuses general opulence, and binds together the universal society of nations by the common and powerful ties of mutual interest and reciprocal obligation. Commerce has enabled each particular state to profit by the inventions and discoveries of every other state. It has given us new tastes and new appetites, and it has also given us the means and the desire of gratifying them. The progress of domestic industry has been accelerated by the competition of foreigners. Commerce has either entirely removed, or greatly weakened, a host of the most unworthy prejudices. It has shown, that nothing can be more illiberal, irrational, and absurd, than that dread of the progress of others in wealth and civilization that was once so prevalent; and it has shown that the true glory and real interest of each particular people will be more certainly advanced by emulating and outstripping each other in the career of science and civilization, than by labouring to attain a barren pre-eminence in the bloody and destructive art of war.

Effect of the Territorial Division of Labour in Augmenting National Wealth.

The influence of commerce in giving increased efficacy to labour, and augmenting national wealth, may be easily illustrated. Thus, in the case of the intercourse, or territorial division of labour, carried on between England and Portugal, it is plain that the superiority of the wool of England, our command of coals, of skilful workmen, of improved machinery, and of all the instruments of manufacturing industry, enables us to produce cloth at a much cheaper rate than the Portuguese: But, on the other hand, the soil and climate of Portugal being peculiarly favourable for the cultivation and growth of the grape, she is enabled to produce wine at an infinitely cheaper rate than it can be produced here. And hence it is obvious, that England, by confining herself to the manufacture of cloth, in which she has a natural advantage on her side, and exchanging it with the Portuguese for wine, will obtain a vastly larger supply of that commodity than if she had attempted to cultivate the grape at home: And Portugal, by exchanging her wine for the cloth of England, will, on her part, obtain a much greater quantity of cloth than if she had attempted to counteract the intention of nature, by converting a portion of her capital and industry from the raising of wine, in which she has an advantage, to the manufacture of cloth, in which the advantage is on the side of another.

Sophism of the French Economists on the Subject of Commerce.

What we have already stated is sufficient to expose the sophism involved in the reasoning of the French economists, who contended, that as an equivalent must be always given for such commodities as are obtained from foreigners, it is impossible foreign commerce can ever become a means of increasing wealth. How, they asked, can the wealth of a country be increased by giving equal values for equal values? They admitted, that commerce might be the means of making a *better distribution* of the wealth of the world; but as it did nothing more than exchange one sort of wealth for another, they denied that it could ever make any addition to that wealth. At first sight, this sophistical and delusive statement appears sufficiently conclusive; but a very few words will be sufficient to demonstrate its fallacy. The advantage of commerce does not consist in its enabling either of the parties who carry it on to obtain commodities of greater value, than those they give in exchange for them. It may have cost as much, or more, to produce the cloth wherewith the English merchant purchases the wine of Portugal, as it did to produce the latter. But then, it must be observed, that in making the exchange, *the value of the wine is estimated by what it takes to produce it in Portugal*, which has peculiar natural capabilities for that species of industry, and *not* by what it would take to produce it in England were the trade put an end to; and, in like manner, the value of the cloth is estimated by what it takes to produce it in England, and not by what it would cost to produce it in Portugal. The advantage of the intercourse between the two countries consists in this, that it enables each of them to obtain commodities, for the production of which they have no natural capability, and which it would, therefore, cost a comparatively large sum to produce directly at home at the price which it costs to produce them in the most favourable circumstances, and with the least possible expence. The gain of the one party is not the loss of the other. Both of them are benefited by this intercourse. For both of them are thereby enabled to save labour and expence in the production of commodities; and the wealth of the two countries is not only better distributed, but it is also positively and greatly increased by the territorial division of labour established between them.

To set this important principle in a clearer point of view, let us suppose that in England a given number of men can, in a given time, manufacture 10,000 yards of cloth, and raise 1000 quarters of wheat, and that the same number of men can, in the same time, manufacture in Poland 5000 yards of cloth and raise 2000 quarters of wheat. It is plain, that the establishment of a free intercourse between the two countries would, in these circumstances, enable England, by manufacturing cloth and exporting it to Poland, to obtain *twice* the quantity of corn in exchange for a given expenditure of capital and labour that she could obtain in return for the same expenditure directly laid out in the cultivation of land at home; and Poland would, on the other hand, be enabled to obtain *twice* as much cloth in exchange for her corn as she could have done had she attempted directly to manufacture it. How ridiculous then to contend, that commerce is not a means of adding to the efficacy of labour, and, consequently, of increasing wealth! Were the intercourse between England and Portugal and the West Indies put an end to, it would require, at the very least, a hundred, or perhaps a thousand times the expence to produce Port wine, sugar, and coffee, directly in this country, that it does to produce the equivalents sent to Portugal and the West Indies in exchange for them.

"The commerce of one country with another is," to use the words of Mr Mill, "merely an extension of that division of labour by which so many benefits are conferred on the human race. As the same

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country is rendered richer by the trade of one province with another; as its labour becomes thus infinitely more divided and more productive than it could otherwise have been; and as the mutual interchange of all those commodities which one province has and another wants, multiplies the accommodations and comforts of the whole, and the country becomes thus in a wonderful degree more opulent and happy; so the same beautiful train of consequences is observable in the world at large, that vast empire of which the different kingdoms may be regarded as the provinces. In this magnificent empire, one province is favourable to the production of one species of produce, and another province to another. By their mutual intercourse, mankind are enabled to distribute their labour as best fits the genius of each particular country and people. The industry of the whole is thus rendered incomparably more productive; and every species of necessary, useful, and agreeable accommodation is obtained in much greater abundance, and with infinitely less expence."—(*Commerce Defended*, p. 38.)

To enter into a more enlarged discussion of this interesting and important subject, would be inconsistent with the object and limits of this article. In our articles on Colonies and the Corn Trade and Laws, we have examined the policy of the restrictions on the colonial trade, and on the corn trade; and in the article Exchange, we have pointed out the circumstances which regulate the importation and exportation of the precious metals; and have shown, that, instead of the excess of exports over imports being any criterion of an advantageous commerce, it is just the reverse, and that it is by *the excess of the value of the imports over the value of the exports* that the direct gains of the merchants, and consequently of the community, are to be estimated. In the fourth book of the *Wealth of Nations*, Dr Smith has examined and refuted the various arguments in favour of the restrictions imposed on the freedom of commerce, in the most able and masterly manner, and with an amplitude of illustration, which leaves nothing to be desired. A very complete exposure of the sophisms of the French economists, on the subject of commerce, may be found in the ingenious and valuable pamphlets of Mr Mill (*Commerce Defended*) and Colonel Torrens (*Economists Refuted*), written in answer to Mr Spence's pamphlet entitled, *Britain Independent of Commerce*. The chapter on *Foreign Trade* in Mr Ricardo's great work is equally original and profound, and deserves to be carefully studied by those who wish to make themselves thoroughly acquainted with the theory of commeree.

Money.

When the division of labour was first introduced, barter was the only method by which commodities were exchanged. But according as society advanced, as the division of employments was extended, and as exchanges became more numerous, the advantage of using some one commodity as a common medium of exchange—as an equivalent for all other commodities, and as a standard by which to ascertain their relative values, soon became obvious. But this is a subject of which we have elsewhere treated at considerable length; and we beg leave to refer our readers for a full investigation of the nature and functions of the common medium of exchange to the article Money in this *Supplement*, and the authorities there quoted.

Accumulation and Employment of Capital.

Accumulation and Employment of Capital.—Capital may be defined to be "*that portion of the produce of labour which is saved from immediate consumption, and employed in maintaining productive industry, or in facilitating production.*" Its accumulation and employment is indispensably necessary to the successful prosecution of almost every branch of industry. Without that species of capital, which chiefly consists of tools and engines, and which has been denominated *fixed*, labour could never be rendered considerably productive; and without that species of capital which chiefly consists of the food and clothes required for the consumption of the labourer during the time he is employed in the production of commodities, and which has been denominated *circulating*, he never could engage in any undertaking which did not yield an almost immediate return. An agricultural labourer, for example, might have an ample supply of carts and ploughs, of oxen and horses, and generally of all the instruments and animals used in his department of industry, but if he were destitute of *circulating* capital, or of food and clothes, he would not be able to avail himself of their assistance, and instead of tilling the ground, would have to betake himself immediately to some species of appropriative industry: And, on the other hand, supposing the husbandman to be abundantly supplied with provisions, what could he do without the assistance of *fixed* capital or tools? What could the most skilful agriculturist perform if he were deprived of his spade and his plough? a weaver if he were deprived of his loom? or a house-carpenter if he were deprived of his saw, his hatchet, and his planes? The accumulation and employment of both fixed and circulating capital is indispensably necessary to elevate any nation in the scale of civilization. And it is only by their conjoined and powerful operation that wealth can be largely produced and universally diffused.

The division of labour is a consequence of the previous accumulation of capital. Before labour can be divided, "A stock of goods of different kinds must be stored up somewhere, sufficient to maintain the labourer, and to supply him with the materials and tools for carrying on his work. A weaver, for example, could not apply himself entirely to his peculiar business, unless there was beforehand stored up somewhere, either in his own possession, or in that of some other person, a stock sufficient for his maintenance, and for supplying him with the materials and implements required to carry on his work, till he has not only completed but sold his web. This accumulation must evidently be previous to his applying himself for so long a time to a peculiar business."—(*Wealth of Nations*, Vol. I. p. 408.)

As the accumulation of stock must have preceded the division of labour, so its subsequent division can only be extended as capital is more and more accumulated. Accumulation and division act and react on each other. The quantity of raw materials which

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the same number of people can work up increases in a great proportion, as labour comes to be more and more subdivided; and according as the operations of each workman are reduced to a greater degree of identity and simplicity, he has, as we have already explained, a greater chance of discovering machines and processes for facilitating and abridging his labour. The quantity of industry, therefore, not only increases in every country with the increase of the stock or capital which sets it in motion; but, in consequence of this increase, the division of labour becomes extended, new and more powerful implements and machines are invented, and the same quantity of labour is thus made to produce an infinitely greater quantity of commodities.

Besides its effect in enabling labour to be divided, capital contributes to facilitate labour, and produce wealth in the three following ways:

Modes in which the Employment of Capital Facilitates Labour.

First.—It enables us to execute work that could not be executed, or to produce commodities that could not be produced without it.

Second.—It saves labour in the production of almost every species of commodities.

Third.—It enables us to execute work better, as well as more expeditiously.

1st, It enables us to produce Commodities that could not be produced without it.

With regard to the first of these modes in which we are benefited by the employment of capital, or to the circumstance of its *enabling us to produce commodities that could not be produced without it*, it is plain that the production of all such commodities as require a considerable period for their completion, could not have been attempted if a stock of circulating capital, or of food and clothes sufficient for the maintenance of the labourer while employed on them, had not been previously provided. But the employment of fixed is frequently as necessary to the production of commodities as the employment of circulating capital. It would be plainly impossible to produce a pair of stockings without the aid of wires; and, although the ground might be cultivated without the aid of the plough, it could not be cultivated without the aid of a spade or a hoe. If we run over the vast catalogue of the various arts practised in a highly polished and civilized country, it will be found that there are very few that can be carried on by the mere employment of the fingers, or tools with which man is furnished by nature. It is almost always necessary to provide ourselves with the results of previous industry, and to strengthen our feeble hands by arming them, if we may so speak, "with the force of all the elements."

2d, It Saves Labour in the Production of Commodities.

In the *second* place, the employment of capital not only enables us to produce many species of commodities that never could have been produced without its co-operation, but it also enables us to *save labour in the production of many others*, and, by lowering their price, brings them within the reach of a far greater number of consumers. We have been so long accustomed to make use of the productive sources of the most powerful machines, that it requires a considerable effort of abstraction to render ourselves fully aware of the real extent of the advantages we derive from them. But if we compare the state of the arts practised alike by civilized man and the savage, we cannot fail to be convinced that it is to the use and employment of fixed capital that we owe a very large proportion of our superior comforts and enjoyments. Consider the advantages which man has derived from the employment of the lower animals, which, in an economical point of view, are regarded only as machines! Consider the advantages that have been derived from the formation of roads, bridges, harbours, and canals—the effect they have had in facilitating the conveyance of commodities, and consequently in distributing them most advantageously, and in reducing their price to the consumer! Consider the advantages that have been derived from the construction of ships, and the improvement of navigation! But it is in vain to attempt even to glance at the numberless benefits which the employment of the fixed capital vested in tools and other instruments, has conferred on society, by cheapening and multiplying necessaries, conveniencies, and luxuries. It is by their means that our fields are cultivated, our houses constructed, our clothes manufactured, our ships built, and the treasures of knowledge and of art transferred from one hemisphere to another! If we consult the history of the human race—if we trace their slow and gradual advancement from barbarism to refinement, we shall be convinced that their progress from their lowest and most abject, to their highest and most polished, state, has been always accompanied, and chiefly promoted, by the accumulation of fresh capital, and the invention and improvement of tools and engines.

3d, It enables us to Execute Work better as well as more Expeditiously.

The *third* advantage derived from the employment of capital consists in the circumstance of its enabling us to execute work *better*, as well as more expeditiously, than it could be done without it. Cotton, for example, might be spun by the hand; but the admirable machinery invented by Hargreaves, Arkwright, and others, has not only enabled us to spin an hundred or a thousand times as great a quantity of yarn as could be spun by means of a common spindle, but it has also improved its quality, and given to it a degree of fineness, and of evenness, or equality, in its parts, which was never previously attained. It would require a painter months, or it might be years, to paint with a brush the cottons, or printed cloths used in the hanging of a single room; and it would be very difficult, if not impossible, for the best artist to give the same perfect identity and sameness to his figures that is given to them by the admirable machinery now in use for that purpose. Not to mention the other and more important advantages of which the invention of moveable types and printing has been productive, it is certain that the beauty of the most perfect manuscript—one on which years of patient and irksome labour have been expended—is unable, in point of delicacy and correctness, to match a well printed work, executed in the hundredth part of the time, and at a hundredth part of the expence required to copy the manuscript. The great foreign demand for English manufactured goods results no less from the superiority of the manufacture, than from their greater

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cheapness; and for both these advantages we are principally indebted to the excellence of our machinery.

The Power to Employ Labour depends on the Amount of Capital.

There are other considerations which equally illustrate the extreme importance of the accumulation and employment of capital. The produce of the labour of a nation cannot be increased otherwise than by an increase in the number of labourers, or by an increase in the productive powers of the existing labourers. But without an increase of capital it is in most cases impossible to employ another workman with advantage. If capital be not augmented, and if the food and clothes destined for the support of the labourers, and the tools and machines with which they are to operate, be all required for the maintenance and efficient employment of the labourers in existence at any given period, there can be no additional demand for them. In such circumstances, the rate of wages cannot rise; and if the number of inhabitants are increased, they must be worse provided for. Neither can the productive powers of the labourer be augmented, without a previous increase of capital. It is only by a better education and training of workmen, by a greater subdivision of their employments, or by an improvement of machinery, that their productive powers can ever be materially increased. But in almost all these cases, an additional capital is required. It is only by means of an additional capital that the workman can be better trained, or that the undertaker of any work can either provide his workmen with better machinery, or make a more proper distribution of employment among them. When the work to be done consists of a number of parts, to keep every man constantly employed in one particular part, requires a much larger stock than where every man is occasionally employed in every different part of the work. "When," says Dr Smith, "we compare the state of a nation at two different periods, and find that the annual produce of its land and labour is greater at the latter than at the former, that its lands are better cultivated, its manufactures more numerous and more flourishing, and its trade more extensive, we may be assured that its capital must have increased during the interval between these two periods, and that more must have been added to it by the good conduct of some, than had been taken from it, either by the private misconduct of others, or by the public extravagance of the government."—(*Wealth of Nations*, Vol. II. p. 23.) It is, therefore, apparent that no country can ever reach the stationary state, so long as she continues to accumulate additional capital. While she does this, she will always have a constantly increasing demand for labour, and will be constantly augmenting the mass of necessaries, luxuries, and conveniencies, and, consequently, also the numbers of her people. But with every diminution of the previous rate at which capital had been accumulating, the demand for labour will decline. When no additions are made to its stock, no more labour will be, or, indeed, can be employed. And should the national capital be diminished, the condition of the great body of the people would be greatly deteriorated—for the wages of labour would be reduced, and pauperism, with all its attendant train of vice, misery, and crime, would spread its ravages throughout the largest portion of society.

Accumulation of Capital.

Having thus endeavoured to point out the vast importance of the employment of capital, and the manner in which it co-operates in facilitating production, we shall proceed to explain the circumstances most favourable for its accumulation. Now, as capital is nothing more than the accumulated produce of previous industry, it is evident its increase will be most rapid where industry is most productive, or, in other words, where *the profits of stock are highest.** The man who can produce a bushel of wheat in *three* days has it in his power to accumulate twice as much as the man who, either from a deficiency of skill, or from his being obliged to cultivate a bad soil, is forced to labour six days to produce the same quantity; and the capitalist who can invest stock so as to yield him a profit of ten *per cent.* has it equally in his power to accumulate twice as fast as the capitalist who can only obtain five *per cent.* for his capital. Conformably to this statement, it is found that the rate of profit, or, which is the same thing, that the power to accumulate capital, is always greatest in those countries which are most rapidly augmenting their wealth and population. The rate of profit, or the power to employ labour and capital with advantage, is ordinarily twice as great in the United States as in Great Britain or France; and it is to this that the more rapid advancement of the former in wealth and population is entirely to be ascribed. We do not mean to say that high profits are *necessarily*, and in *every instance*, accompanied by a great degree of prosperity. Countries with every possible advantage for the profitable employment of industry and of stock, may be subjected to a despotical government, which does not respect the right of property; and the want of adequate security resulting from this circumstance may be of itself sufficient to paralyse all the exertions of those who are otherwise placed in the most favourable situation for the accumulation of capital and of wealth. But we have no hesitation in laying it down as a principle which holds good in every case, and from which there is really no exception, that, *if the governments of any two or more countries be equally liberal, and property in each equally well secured, their comparative prosperity will depend on the rate of profit.* Wherever profits are high, there is a great demand for labour, and the society rapidly augments both its population and its riches. On the

Advantage of High Profits.

* To avoid all chance of misconception, it is necessary to observe, that this refers to *nett* profit, or to the sum which remains to the capitalist after all his outgoings are compensated, including therein a sum sufficient to ensure his capital against risk, and to make up for whatever may be peculiarly disagreeable in his business.

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other hand, wherever they are low, the demand for labour is proportionably reduced, and the progress of society rendered so much the slower.

Parsimony necessary to Accumulation.

But however high the rate of profit, it is evident, that, if men had always *lived up to their incomes*,—that is, if they had always consumed the whole produce of their industry in the gratification of their immediate wants and desires, there could have been no such thing as capital in the world. High profits are advantageous, because they afford the *means* of amassing capital; but something more is necessary to induce us to make *use* of these means, and this is the *accumulating principle*. The desire implanted in the breast of every individual of rising in the world, and improving his condition, has prompted mankind to save a portion of their income, or of the produce of their industry, from immediate consumption, and to set it apart as a fund, or capital, for the support of additional workmen. It is to this principle, therefore, or rather to its effect, *parsimony*, that we owe capital; and it is to capital that we owe almost all our comforts and enjoyments. Without its assistance and co-operation, labour could never have been divided; arts could never have made any progress; and mankind must have continued to shelter themselves, as in the earliest ages, in caves and forests, and to clothe themselves with the skins of wild animals. All the accumulated riches of the world—the cities which cover its surface—the ships which traverse its seas—and all the innumerable variety of improvements, owe their origin to this principle,—to the desire to rise in the world, and, consequently, to save and amass.

It has been wisely ordered, that this principle should be as powerful as it is advantageous. "With regard to profusion," says Dr Smith, "the principle which prompts to expence is the desire of present enjoyment; which, though sometimes violent, and very difficult to be restrained, is in general only momentary and occasional. But the principle which prompts to save is the desire of bettering our condition; a desire which, though generally calm and dispassionate, comes with us from the womb, and never leaves us till we go into the grave. In the whole interval which separates these two moments, there is scarce, perhaps, a single instance in which any man is so perfectly and completely satisfied with his situation as to be without any wish of alteration or improvement of any kind. An augmentation of fortune is the means by which the greater part of men propose and wish to better their condition. It is the means the most vulgar and the most obvious; and the most likely way of augmenting their fortune is to save and accumulate some part of what they acquire, either regularly and annually, or upon some extraordinary occasions. Though the principle of expence, therefore, prevails in almost all men upon some occasions, yet in the greater part of men, taking the whole course of their life at an average, the principle of frugality not only predominates, but predominates very greatly." (*Wealth of Nations*, Vol. II. p. 19.)

It is this principle which carries society forward. The spirit of parsimony, and the efforts which the frugal and industrious classes make to improve their condition, in most instances balance not only the profusion of individuals, but also the more wasteful profusion and extravagance of governments. The spirit of economy has been happily compared by Smith to the unknown principle of animal life—the *vis medicatrix naturæ*,—which frequently restores health and vigour to the constitution, in spite both of disease and of the absurd prescriptions of the physician.

Expenditure of Government, not a Cause of Accumulation.

We must have a care, however, lest we fall into the error of supposing, as Mr Malthus and many others have done, that public expenditure is a cause of individual accumulation. Its effect is, in every instance, distinctly and completely the reverse. The more government spends, the less remains for individuals to save. Necessity may compel a man to exert himself to pay heavy taxes; but it is *choice*, and not necessity, which makes him withdraw a portion of the produce of his industry from immediate consumption, and employ it as a stock. This distinction must be kept constantly in view. It cannot be denied that it is necessity that forces farmers and manufacturers to sell a portion of their produce to pay the taxes to which they are subjected; but when these taxes are paid, the government is satisfied, and it is plainly their own free option—their desire to improve their condition, and to rise higher in the world, and not compulsion, that induces them to accumulate *another* portion of their produce as capital. The capitals of England and of France have not increased, *because* of the vast expenditure of their governments, but in *despite* of it. Those who continued to accumulate, notwithstanding the share of their produce taken from them by government was increased, would evidently have had greater *means* of accumulation, had this share not been increased, or increased in a less proportion. But accumulation, like the other passions, increases as the means of gratifying it increase. In point of fact, the greatest accumulations are invariably made where there is the greatest power to accumulate. There are no internal taxes in America; she is possessed of vast tracts of fertile and uncultivated soil; and industry is, in consequence, extremely productive. And, agreeably to what we have now stated, America doubles her capital and population every five-and-twenty years, and is advancing in the career of wealth and civilization with a rapidity unknown in any other country.

Ambition to rise is the animating principle of society. Instead of remaining satisfied with the condition of their fathers, the great object of mankind in every age has been to rise above it—to elevate themselves in the scale of wealth. To continue stationary, or to retrograde, is not natural to society. Man from youth grows to manhood, then decays and dies; but such is not the destiny of nations. The arts, sciences, and capital of one generation become the patrimony of that which succeeds them; and in their hands are improved and augmented, and rendered more powerful and efficient; so that, if not counteracted by the want of security, or by other adventitious causes, the principle of improvement

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would always operate, and would secure the constant advancement of nations in wealth and population.

It is to this same principle that we owe the discovery and improvement of machinery. Mankind have, in every stage of society, endeavoured to increase their productive powers, and to improve their condition, by availing themselves of the assistance of natural agents, and making them contribute to the performance of tasks which must otherwise have been performed by the hand only. The savage avails himself of the aid of a club and a sling to facilitate the acquisition of game, and abridge his labour; and the same principle which prompted him to resort to and construct these rude instruments, never ceases to operate. It is always producing some new improvement; and in an advanced and refined period, gives us ships for canoes, muskets for slings, steam-engines for clubs, and cotton mills for distaffs. "The hand of man," says Colonel Torrens, "is not armed with any efficient natural instrument, such as the beak of the bird, or the claw of the quadruped, for operating directly upon the materials presented to him; but it is admirably adapted for receiving and applying artificial implements, and for employing the powers of one substance to produce the desired changes in another. Hence almost all the grand results in manufacturing industry are brought about by means of capital. Throughout the world there are no very striking inequalities in the muscular force by which direct labour is performed; and it is mainly owing to the differences in the quantity of capital, and in the skill with which it is applied, that in one country man is found naked and destitute, and that in another all the rude productions of the earth, and all the forces of nature, are made to contribute to his comfort, and to augment his power."—(*On the Production of Wealth*, p. 89.)

Sect. III.—*Different Employments of Capital and Industry—Manufactures and Commerce shown to be equally advantageous as Agriculture—Rate of Profit true test of Individual and Public Advantage.*

Different Employments of Capital and Industry.

We have, in the previous section, endeavoured to show, that the increase and diminution of capital is the grand point on which national prosperity hinges,—that if you increase capital, you instantly increase the means of supporting and employing additional labour, and that if you diminish capital, you instantly take away a portion of the comforts and enjoyments, and perhaps also of the necessaries of the productive classes, and spread poverty and misery throughout the land; and we also endeavoured to show that the increase and diminution of the rate of profit was the great cause of the increase and diminution of capital. If such be the case, it seems impossible to resist coming to the conclusion, that those employments which yield the *greatest profit*, or in which industry is most productive, are the most advantageous. But Dr Smith, Mr Malthus, and most other political economists, have objected to this standard. They allow that if two capitals yield equal profits, the employments in which they are engaged are *equally beneficial to their possessors*; but they contend, that, if one of these capitals be employed in agriculture, it will be productive of greater *public* advantage. We believe, however, that we shall be able to show that this opinion rests on no good foundation; and that the *average rate of profit* is the single and infallible test by which we are always to judge which employment is most and which is least advantageous.

Different Employments of Capital and Industry.

A capital may be employed in *four* different ways, either, *first*, in the production of the raw produce required for the use and consumption of the society; or, *secondly*, in manufacturing and preparing that raw produce for immediate use and consumption; or, *thirdly*, in transporting the raw and manufactured products from one place to another according to the demand; or, *fourthly*, in dividing particular portions of either into such small parcels as suit the convenience of those who want them. The capitals of all those who undertake the improvement or cultivation of lands, mines, or fisheries, are employed in the first of these ways; the capital of all master manufacturers is employed in the second; that of all wholesale merchants in the third; and that of all retailers in the fourth. It is difficult to conceive that a capital can be employed in any way which may not be classed under some one or other of these heads.

Employment of Capital in Agriculture.

On the importance of the employment of capital in the acquisition of raw produce, and especially in the cultivation of the soil, it is unnecessary to enlarge. It is from the soil, including under that term mines and fisheries, that the *matter* of all commodities that either minister to our necessities, our comforts, or our enjoyments, must have been originally derived. The industry which appropriates the raw productions of the earth, as they are offered to us by nature, preceded every other. But these spontaneous productions are always extremely limited. And it is by agriculture only, that is, by the united application of immediate labour and of capital, to the cultivation of the ground, that large supplies of those species of raw produce, which form the principal part of the food of man, can be obtained. It is not quite certain that any of the species of grain, as wheat, barley, rye, oats, &c. have ever been discovered growing spontaneously. But, although this must originally have been the case, still the extreme scarcity of such spontaneous productions in every country with which we are acquainted, and the labour which it requires to raise them in considerable quantities, prove beyond all question that it is to agriculture that we are almost exclusively indebted for them. The transition from the pastoral to the agricultural mode of life is decidedly the most important step in the progress of society. Whenever, indeed, we compare the quantity of food, and of other raw products, obtained from a given surface of a well cultivated country, with those obtained from an equal surface of an equally fertile country, occupied by hunters or shepherds, the powers of agricultural industry in increasing useful productions appear so striking and extraordinary, that we cease to feel surprise at the preference which has been so early and generally given to agriculture over manufactures and commerce; and are disposed to subscribe without hesitation to the panegyric of Cicero when he says, "*Omnium autem rerum ex quibus aliquid acquiritur, nihil est agricultura melius, nihil uberius, nihil dulcius, nihil homine, nihil libero dignius.*"

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Employment of Capital in Manufacturing Industry.

But are there really any just grounds for this preference? Are not manufactures and commerce equally advantageous as agriculture? It is plain that without agriculture we could never possess any considerable supply of the *materials* out of which food and clothes are made; but is it not equally plain, that without a knowledge of the arts by which they are converted into food and clothes, the largest supply of these materials could be of little or no service? The labour of the miller who grinds the corn, and of the baker who bakes it, is equally necessary to the production of bread, as the labour of the husbandman who tills the ground. It is the business of the agriculturist to raise flax and wool; but if the labour of the spinner and the weaver had not given them utility, and fitted them for being made a comfortable dress, they would have been nearly, if not entirely worthless. Without the labour of the miner who digs the mineral from the bowels of the earth, we could not have obtained the matter out of which many of our most useful implements and splendid articles of furniture have been made; but if we compare the ore when dug from the mine with the finished articles, we shall certainly be convined that the labour of the purifiers and refiners of the ore, and of the artists who have afterwards converted it to useful purposes, has been quite as advantageous as the industry of the miner.

Necessity of Manufacturing Industry to the Improvement in Agriculture.

But not only is it certain that manufacturing industry, or that species of industry which fits and adapts the raw produce of nature to our use, is requisite to render its acquisition of any considerable value; but it is also certain, that without manufacturing industry this very raw produce could never have been obtained in any considerable quantity. The labour of the mechanic who fabricates the plough is as efficacious in the producing of corn as the labour of the husbandman who guides it. But the plough-wright, the mill-wright, the smith, and all those artizans who prepare tools and machines for the husbandman, are really manufacturers, and differ in no respect whatever from those who are employed to give utility to wool and cotton, except that they work on *harder* materials. The fixed capital vested in tools and machines is the product of the labour of the tool and engine manufacturer; and without the aid of this fixed capital, it is impossible that agricultural labour, or that any other sort of labour, could ever have become considerably productive.

"Distinguer," says the Marquis Garnier, "le travail des ouvriers de l'agriculture d'avec celui des autres ouvriers, est une abstraction presque toujours oiseuse. Toute richesse, dans le sens dans lequel nous la concevons, est nécessairement le résultat de ces deux genres de travail, et la consommation ne peut pas plus se passer de l'un que de l'autre. Sans leur concours simultané il ne peut y avoir de chose consommable, et par conséquent point de richesse. Comment pourrait-on donc comparer leurs produits respectifs, puisque, en séparant ces deux espèces de travail, on ne peut plus concevoir de véritable produit, de produit consommable et ayant une valeur réelle? La valeur du blé sur pied résulte de l'industrie du moissonneur qui recueillera, du batteur qui le séparera de la paille, du meunier et du boulanger qui le convertiront successivement en farine et en pain, tout comme elle résulte du travail du laboureur et du semeur. Sans le travail du tisserand, le lin n'aurait pas plus le droit d'être compté au nombre des richesses, que l'ortie ou tout autre végétal inutile. A quoi pourrait-il donc servir de rechercher lequel de ces deux genres de travail contribue le plus à l'avancement de la richesse nationale? N'est-ce pas comme si l'on disputait pour savoir lequel, du pied droit ou du pied gauche, est plus utile dans l'action de marcher?"*

No real Difference between Agricultural and Manufacturing Industry.

In fact, there is not at bottom any real distinction between agricultural and manufacturing industry. It is, as we have already shown, a vulgar error to suppose that the operations of husbandry add any thing to the stock of matter already in existence. All that man can do, and all that he ever does, is merely to give to matter that particular form or shape which fits it for his use. But it was contended by M. Quesnay and the French economists, and their opinions have in this instance been espoused by Dr Smith, that the labour of the husbandman in adapting matter to our use is powerfully facilitated by the aid derived from the vegetative powers of nature, while the labour of the manufacturer has to perform every thing itself without any such co-operation.—

Opinion of Dr Smith respecting the Superior Productiveness of Agriculture.

"No equal quantity of productive labour, or capital employed in manufactures," says Dr Smith, "can ever occasion so great a reproduction as if it were employed in agriculture. *In manufactures nature does* NOTHING, *man does* ALL; and the reproduction must always be proportioned to the strength of the agents that occasion it. The capital employed in agriculture, therefore, not only puts into motion a greater quantity of productive labour than any equal capital employed in manufactures, but in proportion, too, to the quantity of productive labour which it employs, it adds a much greater value to the annual produce of the land and labour of the country, to the real wealth and revenue of its inhabitants. *Of all the ways in which a capital can be employed, it is by far the most advantageous to the society.*"—(*Wealth of Nations*, II. p. 53.)

Error of this Opinion.

This is perhaps the most objectionable passage in the *Wealth of Nations;* and it is really astonishing how so acute and sagacious a reasoner as Dr Smith could have maintained a doctrine so manifestly erroneous. It is unquestionably true, that nature powerfully assists the labour of man in agriculture. The husbandman prepares the ground for the seed, and deposits it there; but it is nature that unfolds the germ, that feeds and ripens the growing plant, and brings it to a state of maturity. But does not nature do as much for us in every other department of industry? The powers of water and of wind, which

Nature co-operates with Man in Manufactures and Commerce.

* See page 58 of the *Discours Preliminaire* to the second edition of the translation of the *Wealth of Nations*, by the Marquis Garnier. The same passage is in the first edition, published in 1802.

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move our machinery, support our ships, and impel them over the deep,—the pressure of the atmosphere, and the elasticity of steam, which enable us to work the most stupendous engines, are they not the spontaneous gifts of nature? In fact, the single and exclusive advantage of machinery consists in its having enabled us to press the powers of nature into our service, and to make them perform the principal part of what would otherwise have been wholly the work of man. In navigation, for example, is it possible to doubt, that the powers of nature—the buoyancy of the water, the impulse of the wind, and the polarity of the magnet, contribute fully as much as the direct labour of the sailor to waft our ships from one hemisphere to another? In bleaching and in fermentation the whole process is carried on by natural agents. And it is to the effects of heat in softening and melting metals, in preparing our food, and in warming our houses, that we owe many of our most powerful and convenient instruments, and that these northern climates have been made to afford a comfortable habitation. So far, indeed, from its being true that nature does much for man in agriculture, and nothing in manufactures, that the fact is nearly the reverse. There are no limits to the bounty of nature in manufactures, but there are limits, and not very remote ones, to her bounty in agriculture. The greatest possible amount of capital might be expended in the construction of steam-engines, or of any other sort of machinery, and after they had been multiplied to infinity, the last would be as powerful and as efficient in saving labour and producing commodities as the first. Such, however, is not the case with the soil. Lands of the first quality are speedily exhausted; and it is impossible to apply capital indefinitely even to the best soils, without obtaining from it a constantly diminishing rate of profit. The rent of the landlord is not, as Dr Smith conceived it to be, the recompense of the work of nature remaining, after all that part of the product is deducted which can be regarded as the recompense of the work of man! But it is, as we shall hereafter show, the excess of produce obtained from the best soils in cultivation, over that which is obtained from the worst—it is a consequence not of the increase, but of the diminution of the productive power of the labour employed in agriculture.

Employment of Capital in Commercial Industry.

But if the giving utility to matter be, as it really is, the single and exclusive object of every species of productive industry, it is plain that the capital and labour which is employed in carrying commodities from where they are produced to where they are to be consumed; and in dividing them into minute portions, so as to fit the wants of the consumers, is really as productive as either agriculture or manufactures. The labour of the miner gives utility to matter—to coal for example—by bringing it from the bowels of the earth to its surface; but the labour of the merchant, or carrier, who transports this coal from the mine where it has been dug to the city, or place where it is to be burned, gives it a further, and perhaps a more considerable value. We do not owe our fires exclusively to the miner, or exclusively to the coal merchant. They are the result of the conjoint operations of both, and also of the operations of all those who have furnished them with the tools and implements used in their respective employments.

Advantage of Retail Dealers.

Not only, however, is it necessary that commodities should be brought from where they are produced to where they are to be consumed, but it is also necessary that they should be divided into such small and convenient portions, that each individual may have it in his power to purchase the precise quantity of them he is desirous of obtaining. "If," says Dr Smith, "there was no such trade as a butcher, every man would be obliged to purchase a whole ox or a whole sheep at a time. This would generally be inconvenient to the rich, and much more so to the poor. If a poor workman was obliged to purchase a month's, or six months' provisions at a time, a great part of the stock which he employs as a capital in the instruments of his trade, or in the furniture of his shop, and which yields him a revenue, he would be forced to place in that part of his stock which is reserved for immediate consumption, and which yields him no revenue. Nothing can be more convenient for such a person than to be able to purchase his subsistence from day to day, or even from hour to hour, as he wants it. He is thereby enabled to employ almost his whole stock as a capital. He is thus enabled to furnish work to a greater value, and the profit which he makes by it in this way much more than compensates the additional price which the labour of the retailer gives to the goods. The prejudices of some political writers against shopkeepers and tradesmen are altogether without foundation. So far is it from being necessary, either to tax them, or to restrict their numbers, that they can never be multiplied so as to hurt the public interests, though they may so as to hurt their own individual interests. The quantity of grocery goods, for example, which can be sold in a particular town, is limited by the demand of that town and its neighbourhood. The capital, therefore, which can be advantageously employed in the grocery trade, cannot exceed the capital required to purchase and retail these goods. If this capital is divided between two different grocers, their competition will obviously tend to make both of them still cheaper than if it were in the hands of one only; and if it were divided among twenty, their competition would be just so much the greater, and the chance of their combining together in order to raise the price just so much the less. Their competition might, perhaps, ruin some of themselves; but to take care of this is the business of the parties concerned, and it may safely be trusted to their discretion. It can never hurt either the consumer or the producer; on the contrary, it must tend to make the retailers both sell cheaper and buy dearer, than if the whole trade was monopolized by one or two persons. Some of them, perhaps, may occasionally decoy a weak customer to buy what he has no occasion for. This evil is, however, of too little importance to deserve the public attention, nor would it necessarily be prevented by restricting their number."—(*Wealth of Nations*, II. p. 48.)

Agriculture, Manufactures, and

Thus it appears, that *all* the modes in which capital can be employed in productive industry, or, in

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Commerce, equally advantageous.

other words, that the raising of raw produce, the fashioning of this raw produce after it is raised into useful and agreeable articles, the carrying of the raw and manufactured products from one place to another, and the retailing of them in such portions as may suit the public demand, are *equally* advantageous: that is, the capital and labour employed in any one of these departments contributes equally with the capital and labour employed in the others, to increase the mass of necessaries, conveniencies, and luxuries. Without a previous supply of raw produce, we could have no manufactures; and without manufactures and commercial industry, the greater part of this raw produce would be entirely worthless, and could neither satisfy our wants nor contribute to our comforts. Manufacturers and merchants are to the body politic what the digestive powers are to the human body. We could not exist without food; but the largest supplies of food cannot lengthen our days when the machinery by which nature prepares and adapts this food for our use, and incorporates it with our body, is vitiated and deranged. Nothing, therefore, can be more silly and childish than the estimates that are so frequently put forth of the comparative advantages of agricultural, manufacturing, and commercial industry. They are all intimately and indissolubly connected, and depend upon, and grow out of each other. "Land and trade," to borrow the just and forcible expressions of Sir Josiah Child, "are TWINS, and have always, and ever will, *wax* and *wane together*. It cannot be ill with trade but lands will fall, nor ill with lands but trade will feel it." This reasoning cannot be controverted; and on its authority, we are entitled to condemn every attempt to exalt one species of industry, by giving it factitious advantages at the expence of the rest, as being equally impolitic and pernicious. No preference has ever been given, or can be given, to agriculturists over manufacturers and merchants, or to manufacturers and merchants over agriculturists, without occasioning the most extensively ruinous consequences. Men ought, in every instance, to be allowed to follow their own inclinations in the employment of their stock and industry. Where industry is free, the interests of individuals can never be opposed to the interests of the public. When we succeed best in increasing our own wealth, we must necessarily also succeed best in increasing the wealth of the state of which we are subjects. *

This mutual dependence of the different branches of industry on each other, and the necessity of their co-operation to enable mankind to make any considerable progress in civilization, has been ably illustrated in one of the early numbers of the *Edinburgh Review*. "It may safely be concluded, that all those occupations which tend to supply the necessary wants, or to multiply the comforts and pleasures of human life, are equally productive, in the strict sense of the word, and tend to augment the mass of human riches, meaning, by riches, all those things which are necessary, or convenient, or delightful to man. The progress of society has been productive of a complete separation of employments originally united. At first, every man provided, as well as he could, for his necessities as well as his pleasures, and for *all* his wants, as well as *all* his enjoyments. By degrees a division of these cares was introduced; the subsistence of the community became the province of one class, its comforts of another, and its gratifications of a third. The different operations subservient to the attainment of each of these objects were then entrusted to different hands; and the universal establishment of barter connected the whole of these divisions and subdivisions together—enabled one man to manufacture for all, without danger of starving by not ploughing or hunting, and another to plough or hunt for all, without the risk of wanting tools or clothes by not manufacturing. It has thus become as impossible to say exactly who feeds, clothes, or entertains the community, as it would be to say which of the many workmen employed in the manufacture of pins is the actual pin-maker, or which of the farm-servants produces the crop. All the branches of useful industry work together to the common end, as all the parts of each branch co-operate to its particular object. If you say that the farmer feeds the community, and produces all the raw materials which the other classes work upon, we answer, that unless those other classes worked up the raw materials, and supplied the farmer's necessities, he would be forced to allot part of his labour to this employment, whilst he forced others to assist in raising raw produce. In such a complicated system, it is clear that all labour has the same effect, and equally increases the whole mass of wealth. Nor can any attempt be more vain than theirs who would define the particular parts of the machine that produce the motion, which is necessarily the result of the *whole powers combined*, and depends on each particular one of the mutually connected members."—(Vol. IV. p. 362.)

Manufactures not productive of increased Mortality.

Much has been said respecting the extraordinary mortality of large manufacturing establishments. The ready communication of contagion where people are crowded together—the want of sufficient ventilation—the confinement of children—and the posisive unhealthiness of some particular processes, are circumstances from which most writers have been led to infer that the mortality in manufacturing cities *must* be unusually great, without giving themselves the trouble to inquire whether the fact really was so. The returns under the population acts have shown the fallacy of these opinions. No one can doubt that Great Britain was infinitely more of a manufacturing country in 1810 and 1820 than in 1780; but, notwithstanding the vast increase during the intermediate period of what we have been in the

* For a particular examination of Dr Smith's opinion with respect to the comparative advantages of different species of commerce, see Mr Ricardo's *Principles of Political Economy and Taxation*, 1st ed. p. 497, and the *Edinburgh Review* for July 1819, p. 71.

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habit of considering unhealthy employments, the average mortality in England and Wales in 1810 was only one in every 53, and in 1820 only one in every 58 of the existing population, whereas in 1780 it was one in every 40. It may perhaps be said, that this increased healthiness is owing to the improvements in agriculture—to the drainage of bogs and marshes, the inclosure and cultivation of commons and wastes,—and *not* to the extension of manufactures. But suppose this were admitted, still we should have to inquire *what had occasioned these extraordinary improvements in agriculture?* And a moment's reflection would be sufficient to convince us that they have principally resulted from the improvement of manufactures—from the increased demand of the manufacturing population for the raw produce of the soil. In point of fact, however, it is certain, that much of the late diminution of mortality is a *direct*, and not an indirect consequence of the improvement and extension of manufactures. Every one knows of what vast importance it is to the health of the people that they should have the *means* of providing themselves with comfortable clothes at a cheap rate. And this is one of the many advantages which improvements in manufacturing industry always bring along with them. The reduction in the price of cotton goods only, occasioned by the greater facility with which they are now produced, has enabled the poorest classes of individuals to clothe themselves in a warm, clean, and elegant dress; and has thus been productive of an increase of comfort and enjoyment, of which it is extremely difficult for us, who have so long experienced its beneficial effects, to estimate the extent.

Division of Labour does not degrade the Labourer.

The effect of the extreme subdivision of labour in manufacturing establishments, and the exclusive attention which it requires the workman to bestow on one single operation, has been supposed to exert a most pernicious influence on his mental faculties. The genius of the master is said to be cultivated, but that of the workman to be condemned to perpetual neglect. Most mechanical arts, we are told, succeed best under a total suppression of sentiment and reason. A habit of moving the hand or the foot is said to be independent of either; and the workshop has been compared to an engine, the parts of which are men! (Ferguson *on Civil Society*, p. 303.) Dr Smith, who has given so admirable an exposition of the benefits which society has derived from the division of labour, has notwithstanding concurred with the popular prejudices on this subject; and has gone so far as to affirm that constant application to one particular occupation in a large manufactory, "necessarily renders the workman as *stupid and ignorant as it is possible to make a human being.*" Nothing can be more marvellously incorrect than these representations. Instead of its being true that the workmen employed in manufacturing establishments are less intelligent and acute than those employed in agriculture, the fact is distinctly and completely the reverse. The weavers, and other mechanics of Glasgow, Manchester, and Birmingham, possess infinitely more general and extended information than is possessed by the agricultural labourers of any county in the empire. And this is really what a more unprejudiced inquiry into the subject would have led us to anticipate. The variety of the occupations in which the husbandman is made successively to engage, their constant liability to be affected by so variable a power as the weather, and the perpetual change in the appearance of the objects which daily meet his eyes, and with which he is conversant, occupy his attention, and render him a stranger to that ennui and desire for extrinsic and adventitious excitement which must ever be felt by those who are constantly engaged in burnishing the point of a pin, and in performing the same endless routine of precisely similar operations. This want of excitement cannot, however, be so cheaply or effectually gratified in any other way as it may be by cultivating—that is, by *stimulating* the mental powers. The generality of workmen have no time for dissipation; and if they had, the wages of labour in all old settled and densely peopled countries are too low, and the propensity to save and accumulate too powerful, to permit any very large proportion of them seeking to divert themselves by indulging in riot and excess. They are thus driven to seek for recreation in mental excitement; and the circumstances in which they are placed afford them every possible facility for amusing and diverting themselves in this manner. By working together, they have constant opportunities of entering into conversation; and a small individual contribution enables them to obtain a large supply of newspapers and of the cheaper class of periodical publications. But whatever difference of opinion may exist respecting the *cause*, there can be no doubt of the fact, that the intelligence of the workmen employed in manufactures has increased according as their numbers have increased, and as their employments have been more and more subdivided. We do not believe that they ever were less intelligent than the agriculturists; but, whatever may have been the case formerly, no one will now venture to affirm that they are inferior to them in intellectual acquirements, or that they are mere machines without sentiment or reason. Even Mr Malthus, whose leanings are all on the side of agriculture, has justly and eloquently observed, that "Most of the effects of manufactures and commerce on the general state of society are in the highest degree beneficial. They infuse fresh life and activity into all classes of the state, afford opportunity for the inferior orders to rise by personal merit and exertion, and stimulate the higher orders to depend for distinction upon other grounds than mere rank and riches. They excite invention; encourage science and the useful arts; spread intelligence and spirit; inspire a taste for conveniencies and comforts among the labouring classes; and, above all, give a new and happier structure to society, by increasing the proportion of the *middle classes*—that body on which the liberty, public spirit, and good government of every country must mainly depend." (*Observations on the Effects of the Corn Laws*, p. 29.)

Eulogium of Mr Malthus on Manufactures.

Rate of Profit true Test of the advantage of different Employments.

Thus, then, we arrive, by a different *route*, at the same result we have already endeavoured to establish. The inextinguishable passion for gain—the *auri sacra fames*—will always induce capitalists to employ their stocks in those branches of industry which yield, all things considered, the *highest rate of profit*. And it is clear to

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demonstration, that those employments which yield the highest profits are always those in which it is most for the public interest that capital should be invested. The profits of a particular branch of industry are rarely raised except by an increased demand for its produce. Should the demand for cottons increase, there would be an increased competition for them; and as their price would, in consequence, be augmented, the manufacturers would obtain comparatively high profits. But the rate of profit in different employments has a natural tendency to equality; and it can never, when monopolies do not interpose, continue either permanently higher or lower in one than in the rest. As soon, therefore, as the rise in the price of cottons had taken place, additional capital would begin to be employed in their production. The manufacturers engaged in the cotton trade would endeavour to borrow additional capital, and the capitalists who were engaged in less lucrative employments would gradually contract their businesses, and transfer a portion of their stock to where it would yield them a larger return. The equilibrium of profit would thus be again restored. For the additional capital employed in the production of cottons, by proportioning their supply to the increased demand, would infallibly reduce their price to its proper level. Such is the mode in which the interests of individuals are, in every case, rendered subservient to those of the public. High profits attract capital; but high profits in particular businesses are the effect of high prices; and these are always reduced, and the commodities brought within the command of a greater number of purchasers, as soon as additional capital has been employed in their production. It is clear, therefore, that that employment of capital is the best which yields the greatest profit; and hence, if two capitals yield *equal* profits, it is a plain proof that the departments of industry in which they are respectively invested, however much they may differ in many respects, are equally beneficial to the country. Nothing can be more nugatory than to apprehend that the utmost freedom of industry can ever be the means of attracting capital to a comparatively disadvantageous employment. If capital flows to manufactures or commerce rather than to agriculture, it can only be because it has been found to yield larger profits to the individual, and consequently to the state.

Part III.—Distribution of Wealth.

Having thus endeavoured to trace the various methods by which that labour which is the only source of wealth may be rendered most productive, and to exhibit the mutual relation and dependence of the different kinds of industry, we now proceed to the *second division* of our subject, or to an investigation of the laws regulating the proportions in which the various products of art and industry are distributed among the various classes of the people.

Sect. I.—*Primary Division of the Produce of Industry—Value of Commodities measured in the Earliest Stages of Society by the Quantities of Labour expended on their Production.*

It is self-evident that only three classes—the labourers, the possessors of capital, and the proprietors of land, are ever directly concerned in the production of commodities. It is to them, therefore, that all that is derived from the surface of the earth, or from its bowels, by the united application of immediate labour and of capital, or accumulated labour, must *primarily* belong. The other classes of society have no revenue except what they derive either voluntarily, or by compulsion, from these three classes.

Primary Division of the Produce of Industry.

But although there is no state of society in which any other class besides those of labourers, landlords, and capitalists, participates directly in the produce of industry, there are states of society in which that produce belongs exclusively to *one* only of these classes; and others in which it belongs to *two* of them, to the exclusion of the third. The reason is, that, in the earliest stages of society, there is little or no capital accumulated, and the distinction between labourers and capitalists is, in consequence, unknown; and that in all newly settled and unappropriated countries, abundance of fertile land may be obtained without paying any rent.

In that remote period preceding the establishment of a right of property in land, and the accumulation of capital or stock—when men roamed, without any settled habitations, over the surface of the earth, and existed by means of that labour only that was required to appropriate the spontaneous productions of the soil, the whole produce of labour would belong to the labourer, and the *quantity of labour* that had been expended in the procuring of different articles, would plainly form the only standard by which their relative worth, or exchangeable value, could be estimated. "If among a nation of hunters," says Dr Smith, "it usually costs twice the labour to kill a beaver that it does to kill a deer, one beaver would naturally exchange for or be worth two deer. It is natural, that what is usually the produce of two days' or two hours' labour, should be worth double of what is usually the produce of one day's or one hour's labour.

Quantity of Labour the regulating Principle of Value.

"If the one species of labour should be more severe than the other, some allowance will naturally be made for this superior hardship; and the produce of one hour's labour in the one way, frequently exchanges for that of two hours' labour in the other.

"Or if the one species of labour requires an uncommon degree of dexterity and ingenuity, the esteem which men have for such talents will naturally give a value to their produce, superior to what would be due to the time employed about it. Such talents can seldom be acquired but in consequence of long application, and the superior value of their produce may frequently be no more than a reasonable compensation for the time and labour which must be spent in acquiring them. In the advanced state of society, allowances of this kind, for superior hardship and superior skill, are commonly made in the wages of labour; and something of the same kind must probably have taken place in the earliest and rudest period.

"In this state of things, the whole produce of labour belongs to the labourer; and the quantity of labour commonly employed in acquiring or producing any commodity, is the only circumstance which

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can regulate the quantity of labour (*of other commodities*) which it commonly ought to purchase, command, or exchange for."—(*Wealth of Nations*, I. p. 70.)

Thus far there is no room for doubt or difference of opinion. When there is no class but labourers, *all* the produce of labour must obviously belong to them; and the *quantity of labour* required to produce commodities must form the only standard by which their exchangeable worth or value can be estimated. It is at this point, therefore, that we are to begin the investigation of the laws regulating the division of the produce of industry among the three great classes of labourers, capitalists, and landlords; and we shall do this by endeavouring, in the first place, to acquire a knowledge of the laws which regulate the *exchangeable value* of commodities in an advanced period of society, when circulating and fixed capital are employed in their production, and when land is appropriated, and rent paid. A previous acquaintance with the circumstances which determine the value of commodities, will be found to be indispensable to enable us to ascertain the principles which regulate their distribution.

Sect. II.—*Preliminary Considerations—Equality of Wages and Profits—Inquiry into the Effect of Variations of Demand and Supply on Price—Cost of Production shown to be its regulating Principle.*

Preliminary Considerations.

If the popular opinions on this subject were well founded, the inquiry on which we are now about to enter might be disposed of in a very few words. The exchangeable value of commodities, when compared with each other, and their value or price when compared with money, is held almost universally to depend on their *relative abundance or scarcity in the market, compared with the demand.* We believe, however, that we shall be able to show, that this opinion rests on no good foundation, and that it is the *cost of production* which is the sole regulating principle of price. But, before proceeding further, it is necessary, in order to facilitate our investigations in this and the following sections, to premise, that wherever industry is free, *the rate of wages earned by the labourers engaged in any particular department of industry, and the rate of profit derived from the capital vested in it, cannot, for any considerable period, either fall below, or rise above, the rate of wages and profits accruing to the labourers and capitalists engaged in other departments.*

Equality of the Wages earned by the Labourers engaged in different Branches of Industry.

With regard to the *first* of these positions, or to the equality of the wages earned by the labourers engaged in different employments, it is not meant to infer that all labourers receive precisely the same sum of money, or the same *proportional share* of the produce of their labour. Such an opinion would be equally at variance with the fact,—and with the principle it is our object to elucidate. Wages are a compensation given to the labourer in return for the exertion of his physical powers, or of his skill, or ingenuity. They must, therefore, vary according to the greater intensity of the labour to be performed, and to the degree of skill and ingenuity required. Wages would not be equal if a jeweller or engraver, for example, received no higher rate than a common farm servant, or a scavenger. A long course of training is required to instruct a man in the business of jewelling and engraving; and if this were not compensated, by a higher rate of wages, it is evident no one would choose to learn so difficult an art; but would addict himself in preference to such employments as hardly require any training. The cost of producing artificers, or labourers, regulates the wages they obtain, precisely in the same way that the cost of producing commodities regulates their value. A man who practises a difficult or nice business, loses all the time that is spent in his apprenticeship, and generally also the clothes and provisions consumed by him during the same period. This person ought, therefore, to obtain not only the same rate of wages as husbandry labourers, and those who do not require to serve an apprenticeship, but he ought also to obtain an additional rate proportioned to the extra time and expence spent in learning his business. If he does not obtain this additional rate, it is plain he would not be so well paid as the husbandry labourers; and if he obtained *more* than what was a fair and reasonable compensation for the greater expence to which he had been put, there would be an immediate influx of labourers into that particular business, and competition would not fail to reduce wages to their proper level.

Equality of Wages and Profits.

Besides this prominent cause of apparent inequality, wages vary in amount proportionably to the ease and hardship, the agreeableness and disagreeableness, the constancy and inconstancy of employment. In the greater part of manufactures, a journeyman may, except in periods of general revulsion, generally be able to obtain constant employment. But there are several businesses, such, for example, as those of masons and bricklayers, that can neither be carried on in hard frost nor foul weather. Their earnings must therefore be able not only to maintain them while they are employed, but also while they are idle, and to make them some compensation for those anxious and desponding moments which the thought of so precarious a situation must sometimes occasion. Hence, says Dr Smith, "where the daily earnings of the greater number of manufacturers are nearly upon a level with the daily earnings of the superior class of farm servants, the wages of masons and bricklayers are generally from fifty to one hundred *per cent.* higher. Where common labourers earn four or five shillings a week, masons and bricklayers frequently earn seven and eight; and where the former earn nine or ten, the latter commonly earn fifteen and eighteen."—(*Wealth of Nations,* I. p. 157.)

But these variations, instead of being inconsistent with the principle we have been endeavouring to establish, plainly result from it. The wages earned by different classes of workmen are equal, not when each earns the same number of shillings or of pence, in a given space of time—but when each is paid in proportion to the severity of the labour he has to perform, to the degree of previous education and of skill that it requires, and to the other causes of variation. So long, indeed, as the principle of competition is allowed to operate without restraint, or so long as each individual is allowed to employ himself as he pleases, we may be assured that the higgling

Equality of Wages and Profits.

of the market will always adjust the rate of wages in different employments on the principle we have now mentioned, and that it will be very nearly equal. If the rate of wages in one department were depressed below the common level, labourers would leave it to go to others; and if it were to rise above this common level, then, it is plain, labourers would be attracted from those departments where wages were lower, until the increased supply had sunk them to their just level. A period of greater or less duration, according to the circumstances of the country at the time, is always required to bring about this equalization. But all theoretical inquiries, and such as have the establishment of principles for their object, either are, or ought to be, founded on periods of average duration; and whenever such is the case, we may always, without occasioning the slightest error, assume, that the wages earned in different employments are, all things considered, *precisely equal.*

Equality of the Profits of the Capital employed in different Businesses.

In like manner, the profit accruing to the capitalists engaged in different businesses must always vary proportionably to the greater or less risk, and other circumstances specially affecting the capital they employ in them. It is obvious, indeed, that profits have not attained their level until they have been adjusted so as to balance these different advantages and disadvantages. None would engage in unusually hazardous undertakings, if the capital employed in them only yielded the same profit that might have been obtained by employing it in more secure businesses. No one would choose voluntarily to place his fortune in a situation of comparative danger. Wherever there is extraordinary risk, that risk must be compensated. And hence, the well known distinction between *gross* and *nett* profit. Gross profit always varies according to the risk, the respectability, and the agreeableness of different employments, while nett profit is the same, or very nearly the same, at any particular period, in them all. A gunpowder manufacturer, for example, must obtain as much profit, over and above the profit obtained from the capital engaged in the securest businesses, as will suffice to guarantee or *insure* his capital, from the extraordinary risk to which it is exposed, in a business of such extreme hazard. If the gunpowder manufacturer were to obtain *more* than this rate, additional capital would be attracted to his business, and if he were to obtain *less,* he would withdraw capital from it. The great and constantly acting principle of competition, or, which is just the same thing, the *self-interest* of every individual will never permit the wages or the profits obtained by any particular set of workmen or capitalists, taking all things into account, to continue either long below or long above the *common and average* rate of wages and profits obtained by those who are employed, or who have capital invested in other businesses. It is by this common standard that the wages and profits of particular businesses are always regulated; they can never diverge considerably from it; they have a constant tendency to equalization; and may, in all theoretical inquiries, be supposed, without occasioning any error of consequence, exactly to coincide.

The principle of the equality, or rather of the constant tendency to equality, of the wages earned by the labourers, and of the profits derived from the capital, employed, at the same time, in all the various branches of industry, was pointed out by Mr Harris, and also by Mr Cantillon, in his work entitled, *The Analysis of Trade,* &c. published in 1759; but it was first fully demonstrated in the eighth, ninth, and tenth chapters of the first book of the *Wealth of Nations.* The establishment of this principle was one of the greatest services rendered by Dr Smith to the science of Political Economy. Nothing can be clearer, more convincing and satisfactory, than his reasoning on this subject. The equality of wages and of profits has, ever since the publication of his work, been always assumed as admitted and incontestible.

Variations of Demand and Supply exert no permanent influence on Price.

The principle of the equality of wages and profits once established, it is easy to show that variations in the demand and supply of commodities can exert no lasting influence on price. It is the *cost of production*—denominated by Smith and the Marquis Garnier *necessary,* or *natural price*—which is the permanent and ultimate regulator of the exchangeable value or price of every commodity which is not subjected to a monopoly, and *which may be indefinitely increased in quantity by the application of fresh capital and labour to its production.* That the market price of such commodities and the cost of production do not always coincide is certain; but they cannot, for any considerable period, be far separated, and have a constant tendency to equality. It is plain that no man will continue to produce commodities if they sell for *less* than the cost of their production—that is, for less than will indemnify him for his expences, and yield him the common and average rate of profit on his capital. This is a limit below which it is obviously impossible prices can be permanently reduced; and it is equally obvious, that if they were, for any considerable period, to rise above it, additional capital would be attracted to the advantageous business, and the competition of the producers would lower prices.

The Will and the Power to Purchase necessary to constitute Demand.

A demand, to be effectual, must be such as will cover the expence of production. If it is not sufficient to do this, it can never be a means of causing commodities to be produced and brought to market. A real demander must have the *power,* as well as the *will,* to purchase. A person with 20s. in his pocket may be as anxious,—nay, he may be ten times more anxious, to become the purchaser of a coach than of a hat; why then does he not obtain the one as readily in exchange for his 20s. as the other? The reason is obvious—20s. will pay the expence of producing the one, and it will *not* pay the expence of producing the other. But if such an improvement were to take place in the art of coachmaking, as would enable any one to produce a coach as cheaply as a hat, then 20s. would buy a coach as easily as it can now buy a hat. The demand for any particular commodity may become ten or ten thousand times more extensive, or it may decline in the same proportion; but if the cost of its production continues the same, no permanent variation will be occasioned in its price. Suppose, for example, that the demand for hats is suddenly doubled, that circumstance would undoubtedly occasion a rise of price, and the hatters would, in consequence, make large profits; but this rise

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could only be of very limited duration; for the large profits would immediately attract additional capital to the hat manufacture; an increased supply of hats would be brought to market, and if no variation took place in the cost of production, their price would infallibly sink to its former level. Suppose, on the other hand, that the demand for hats is increased a thousand fold, and the cost of producing them diminished in the same proportion, we should, notwithstanding the increased demand, be able, in a very short time, to buy a hat for the thousandth part of what it now costs. Again, suppose the demand for hats to decline, and the cost of producing them to increase, the price would, notwithstanding the diminished demand, gradually rise, till it had reached the point at which it would yield the hatters the common and average rate of profit on the capital employed in their business. It is admitted that variations in the demand and supply occasion temporary variations of price. But it is essential to remark, that these variations are only *temporary*. It is the *cost of production* that is the grand regulator of price—the centre of all those transitory and evanescent oscillations on the one side and the other; and wherever industry is free, the *competition of the producers* will always elevate or sink prices to this level.

Cost of Production the regulating Principle of Price.

In certain branches of industry, such, for example, as agriculture, which are liable to be seriously affected by the variations of the seasons, and from which capital cannot be easily withdrawn, there is a somewhat longer interval than in others, before the market price of produce and the cost of producing it can be equalized. But that such an equalization will be brought about in the end is absolutely certain. No farmer, and no producer whatever, will continue to bring corn or other products to market, if they do not sell for such a price as will pay the expence of their production, including therein the common and average rate of profit on the capital employed by them.* An excess of supply has now (January 1823) depressed the prices of corn and other farm produce below this level; and the occupiers of poor land are, in consequence, involved in the greatest difficulties; but most assuredly this glut will not continue. A part of the cultivators of poor soils will be driven from their employment. A smaller supply will be brought to market; and prices will be adjusted so as to yield the customary rate of profit, and no more, to the agriculturists who continue the cultivation of the poorest soils.—The self-interest of the cultivators will not permit prices to be permanently depressed below this level; and the self-interest of the public will not permit them to be permanently raised above it; for, if they were raised above it, then the cultivators would gain more than the common and average rate of profit, and capital would, of course, be immediately attracted to agriculture, and would continue flowing in that direction, until the natural and indestructible equilibrium of profit had been restored—that is, as we shall afterwards show, until the price of agricultural produce had fallen to such a sum as would just yield the average rate of profit to the cultivators of the worst soils, or the improvers of the best. This is the point at which *average* prices must continue stationary, or about which market prices must oscillate, until the cost of production be increased or diminished. If any great discovery were made in agriculture—such a discovery, for instance, as would reduce the cost of cultivation a half, the price of agricultural produce would fall in the same proportion, and would continue to sell at that reduced rate until the increase of population forced recourse to soils of a *decreasing degree of fertility*. Whenever this took place, prices would again rise. Why is the price of corn almost invariably higher in this country than in France? Is it because we have a greater demand for it, or because of the greater cost of production in this country?

Reason why Gold is more valuable than Silver.

A pound weight of gold is at present worth about *fifteen* pounds of silver. It cannot, however, be said that this is a consequence of the demand for gold being greater than the demand for silver, for the reverse is the fact. Neither can it be said to be a consequence of an absolute scarcity of gold; for, those who choose to pay a sufficient price for it may obtain it in any quantity they please. The cause of this difference in the price of the two metals consists entirely in the circumstance of its costing about *fifteen* times as much to produce a pound of gold as to produce a pound of silver. That this is really the case, is plain from the admitted fact that the producers of gold do not gain any greater profit than the producers of silver, iron, lead, or any other metal. They have no monopoly of the business. Every individual who pleases may send capital to Brazil, and become a producer of gold; and wherever this is the case, the principle of competition will always force the product to be sold at such a price as will just pay the expences of its production and no more. Were a gold mine discovered of equal productiveness with the silver mines, the production of gold would immediately become the most advantageous of all businesses; an immense supply of that metal would, in consequence, be thrown on the market, and its price would, in a very short period, be reduced to the same level as silver.

Reason why Cottons have declined in Price.

As a further illustration of this principle take the case of cottons. No one can deny that the demand for them has been prodigiously augmented within the last fifty or sixty years; and yet their price, instead of increasing, as it ought to have done, had the popular theory of demand and supply been well-founded, has been constantly and rapidly diminishing. If it is said that this is a consequence of the

* Some of the advocates of the agricultural interest have represented this as one of the "dangerous dogmas" of the Scotch Economists! But it can boast of a much more remote origin:—"*Nemo enim sanus*," says Varro, "*debet velle impensam ac sumptum facere in culturam, si videt non posse refici.*" (*De Re Rustica*, Lib. I. § 2.)

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supply of cottons having augmented in a still greater ratio than the demand, we answer that this is not enough to explain the fall of price. The supply would not and could not possibly have been brought to market, had not the constant diminution of prices, which has been going on since the invention of spinning-jennies in 1767, been balanced by an equal diminution of the cost of production. It is to this principle—to the vastly increased facility of production, occasioned by the stupendous inventions and discoveries of Hargreaves, Watt, Arkwright, Crompton, and others, that the lower price and increased demand for cottons is exclusively owing. The increased facility of production has brought them within the reach of all classes of the people; and enabled the poorest individuals in the kingdom to clothe themselves in a dress which, at the accession of George III. was fully as expensive as silk.

Competition of the Producers in a Civilized Society will always sink Prices to the Cost of Production.

If you bring a set of men together from various countries who are ignorant of each other's wants, and of the labour and expence necessary to produce the commodities which each possesses, the commodities will be bought and sold according to the relative wants and fancies of the parties. In such circumstances, a pound of gold might be given for a pound of iron, and a gallon of wine for a gallon of small beer. As soon, however, as a commercial intercourse has been established, and as the wants of society and the powers of production come to be well and generally known, an end is put to this method of bartering. Thousands of sellers then enter the market. But when such is the case, it is no longer possible to sell a pound of gold for a pound of iron; and why? because the producers of iron will undersell each other until they have, by their competition, reduced its price to such a sum as will just suffice to pay the expence of its production. This is in every civilized society the pivot on which exchangeable value always turns. A civilized man might be able to obtain commodities from a savage, in exchange for toys or trinkets, which it cost infinitely less to produce; but if he tries to obtain the same advantage over his own countrymen, a very short experience will be enough to satisfy him that they are quite as clear-sighted and attentive to their own interests as he is.

Thus, then, it appears, that *no variation of demand, if it be unaccompanied by a variation in the cost of production, can have any lasting influence on price.* If the cost of production be diminished, price will be equally diminished, though the demand should be increased to any conceivable extent. If the cost of production be increased, price will be equally increased, though the demand should sink to the lowest possible limit.

Influence of Monopolies.

It must always be remembered, that this reasoning only applies to the case of those commodities on which competition is allowed to operate without restraint, and whose quantity can be indefinitely increased by the application of fresh capital and industry to their production. When a particular individual, or class of individuals, obtain the exclusive privilege of manufacturing certain species of goods, the operation of the principle of competition is suspended with respect to them, and their price must, therefore, entirely depend on the proportion in which they are brought to market compared with the demand. If monopolists supplied the market liberally, or kept it always as fully stocked with commodities as it would have been had there been no monopoly, the commodities produced by them would sell at their natural price, and the monopoly would have no further disadvantage than the exclusion of the public from an employment which every one ought to have the right of carrying on. In point of fact, however, the market is never fully supplied with commodities produced under a monopoly. Every class of producers naturally endeavour to obtain the highest possible price for their commodities; and if they are protected by means of a monopoly, against the risk of being undersold by others, they will either keep the market understocked, or supply it with inferior articles, or both. In such circumstances, the price of the commodity, if it cannot be easily smuggled from abroad, or clandestinely produced at home, will be elevated to the highest point to which the competition of the *buyers* can raise it, and may, in consequence, be sold for five, ten, or twenty times the sum for which it would be offered were competition permitted to operate in its production. The *will* and *power* of the purchasers to offer a high price forms the only limit to the rapacity of monopolists.

Besides the commodities produced under an artificial monopoly, there is another class whose quantity cannot be increased by the operation of human industry, and whose price is not, therefore, dependent on the cost of their production. Ancient statues, vases, and gems, the pictures of the great masters, some species of wines which can be produced in limited quantities only from soils of a particular quality and exposure, and a few other commodities, come under this description. As their supply cannot be increased, their price must vary inversely as the demand, and is totally unaffected by any other circumstance.

Average Price always coincident with Cost of Production.

But with these exceptions, which, when compared to the great mass of commodities, are extremely few and unimportant, wherever industry is unrestricted and competition allowed to operate, the *average* price of the various products of art and industry, always coincides with the cost of their production. When a fall takes place in the market price of any commodity, we cannot say whether that fall is really advantageous, or whether a part of the wealth of the producers be not gratuitously transferred to the consumers, until we learn whether the cost of production has been equally diminished. If this is the case, the fall of price will not have been disadvantageous to the producers, and will be permanent; but if this has not been the case—if the cost of production continues the same, the fall must have been injurious to the producers, and prices will, in consequence, speedily attain their former level. It is the same with a rise of prices. No rise can be permanent except where the cost of production has been proportionably increased. If that cost has remained stationary, or has not increased in a corresponding ratio, prices will decline as soon as the ephemeral causes of enhancement have disappeared.

The extreme importance of having correct opi-

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nions respecting the regulating principle of price, and the discordant and erroneous opinions that are still so exceedingly prevalent with regard to it, will, we hope, be deemed a sufficient apology for the length of the previous remarks, and for the insertion of the following paragraph from the *Histoire de la Monnaie* of the Marquis Garnier, in which the doctrine we have been endeavouring to establish is enforced with equal ability and eloquence:

Opinion of the Marquis Garnier.

"Mais les producteurs tendent continuellement à régler la quantité des productions sur la somme des demandes; ils ne resteront pas au-dessous de ce point, sans être tentés d'accroître la masse de leurs produits; et ils ne peuvent le dépasser sans s'exposer à perdre. Ces deux quantités, celle des produits et celle des demandes, s'efforcent donc à se mettre en équilibre l'une avec l'autre. Il existe donc un point de repos vers lequel elles gravitent chacune de son côté; un point qui est leur niveau, et c'est ce point qui constitue le *prix naturel* de la chose vénale. Quelle est la limite au-delà de laquelle le producteur ne peut porter la quantité de ses produits? C'est le prix naturel; car, s'il ne peut obtenir ce prix pour tout son produit, il sera en perte. Quelle est la borne des demandes du consommateur? C'est le prix naturel; car il ne veut pas donner plus que l'équivalent de ce qu'il reçoit. Si, par une découverte, ou par un perfectionnement de l'industrie, le producteur est mis à même d'établir l'article sur lequel il s'exerce à moins de temps et de dépense, alors le prix naturel baissera, mais aussi la somme des demandes accroîtra dans une proportion pareille, parce que plus de consommateurs seront en état de payer ce prix naturel, moins élevé que l'ancien. *Le prix naturel sera toujours, pour chaque chose vénale, la limite commune au-delà de laquelle la somme des demandes de cette chose et la quantité de sa production ne devront plus faire de progrès.* Quand le prix courant est le prix naturel, le producteur et le consommateur se donnent réciproquement l'équivalent de ce qu'ils reçoivent. Quand le prix courant s'écarte du prix naturel, ou c'est la consommation qui souffre au profit de la production, ou c'est la production qui souffre au profit de la consommation. Cet état de souffrance ne peut durer, et de-là procèdent les variations du prix courant. Ces variations, que Smith a expliquées et analysées avec une si parfaite lucidité, ne sont autre chose que les efforts pour revenir au prix naturel. Tenter d'expliquer ces variations, sans reconnaître l'existence d'un prix naturel, ce serait vouloir expliquer les oscillations du pendule sans convenir de sa tendance vers un centre de gravitation; ce serait supposer un effort sans but et sans mobile; ce serait admettre le mouvement et nier le repos; enfin, en voyant les phénomènes du cours des fluides et de l'équilibre des solides, ce serait contester les lois du niveau et de la pesanteur. Si les choses vénales n'ont point de prix naturel, alors les mouvemens de la circulation seront dirigés par une force aveugle et inconnue; les prix moyens ne seront plus que le résultat de chances purement fortuites; il n'y aura plus d'équivalent réel; les valeurs n'auront plus de mesure naturelle; l'économie politique ne pourra plus aspirer à être au rang des sciences, puisqu'elle manquera du caractère essentiel qui les constitue telles, et que les faits dont elle traite ne seront plus fondés sur les lois immuables de la nature."—(Tome 1. *Introduction*, p. 62.)

Nature and Causes of Rent.

Having thus shown that it is the *cost of production* which is the sole regulating principle of price, we shall now proceed to investigate the elements which enter into and constitute the cost of producing commodities in an advanced state of society, when a rent is paid for land, and circulating and fixed capital employed to facilitate the labour of the workman. This is, of all others, the most important, as it is the most radical inquiry in the science of the distribution of wealth; and it is indeed impossible, without possessing accurate notions on this subject, to advance a single step without falling into errors. We shall begin by endeavouring to ascertain whether rent enters into the cost of production, or not.

SECT. III.—*Nature, Origin, and Progress of Rent—Not a Cause but a Consequence of the High Value of Raw Produce—Does not enter into Price—Distinction between Agriculture and Manufactures.*

Dr Smith was of opinion, that, after land had become property, and rent began to be paid, such rent made an equivalent addition to the exchangeable value of the produce of the soil. (*Wealth of Nations*, I. p. 75.) This opinion was first called in question in two pamphlets of extraordinary merit, published nearly at the same time, by Mr Malthus,* and a Fellow of University College, Oxford. † These writers endeavoured to show that rent was not, as had been generally supposed, a consequence of land being appropriated and of limited extent, but of the superior productiveness of one species of land over another; and that the annihilation of rents would not, provided the same extent of land was cultivated, enable its produce to be sold at a lower price. Mr Ricardo has illustrated and enforced this doctrine with his usual ability—has stripped it of the errors by which it had been encumbered, and has shown its vast importance to a right understanding of the laws which regulate the rise and fall of profits. But the subject is still far from being exhausted; and we hope to be able to treat it in a somewhat different manner from what it has been treated by either of these gentlemen, and to obviate some rather specious objections which have not come under their notice.

Definition of Rent.

Rent is properly "that portion of the produce of the earth which is paid by the farmer to the landlord for the use of the *natural and inherent* powers of the soil." If buildings have been erected on a farm, or if it has been inclosed, drained, or in any way improved, by an expenditure of capital and labour, the sum which a farmer will pay to the land-

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* *An Inquiry into the Nature and Progress of Rent*, by the Rev. T. R. Malthus, 1815.

† *An Essay on the Application of Capital to Land*, by a Fellow of University College, Oxford, 1815.

Nature and Causes of Rent.

lord for its use will be composed, not only of what is properly rent, but also of a remuneration for the use of the capital which has been laid out in its improvment. In common language, these two sums are always confounded together, under the name of rent; but in an inquiry of this nature, it is necessary to consider them as perfectly distinct. The laws by which rent and profits are regulated being totally different, those which govern the one cannot be ascertained if it be not considered separately from the other.

No Rent paid on the first settling of any Country.

On the first settling of any country abounding in large tracts of unappropriated land, no rent is ever paid; and for this plain and obvious reason, that no person will pay a rent for what may be procured in unlimited quantities for nothing. Thus in New Holland, where there is an ample supply of fertile and *unappropriated* land, it is certain, that, until the best lands are all cultivated, no such thing as rent will ever be heard of. Suppose, however, that tillage has been carried to this point, and that the increasing demand can, in the actual state of the science of agriculture, be no longer supplied by the best lands, it is plain that either the increase of population must cease, or the inhabitants must consent to pay such an additional price for raw produce as will enable the *second* quality of land to be cultivated. No advance *short of this* will procure them another bushel of corn; and competition will not, as we shall immediately show, allow them to pay more for it. They have, therefore, but one alternative. If they choose to pay a price sufficient to cover the expence of cultivating land of the second quality, they will obtain additional supplies; if they do not, they must want them. Suppose, now, that the consumers offer such a price as will pay the expence of producing corn on soils which, in return for the same expenditure as would have produced 100 quarters on lands of the *first quality,* will only yield 90 quarters; it is plain it will then be just the same thing to a farmer whether he pays a rent of ten quarters for the first quality of land, or farms the second quality, which is unappropriated and open to him, without paying any rent. If the population went on increasing, lands which would yield only 80, 70, 60, 50, &c. quarters in return for *the same expenditure that had obtained* 100 *quarters from the best lands*, might be successively brought under cultivation. And when recourse had been had to these inferior lands, the rent of the land of the higher qualities would plainly be *equal to the difference, or the value of the difference, between their produce and the produce of the worst quality under cultivation.* Suppose, for example, that the worst quality under cultivation yields 60 quarters, then the rent of the *first* quality will be 40 quarters, or 100—60; the rent of the *second* quality would, in like manner, be equal to the difference between 90 and 60, or 30 quarters; the rent of the third quality would be equal to 80—60, or 20 quarters, and so on. The produce raised on the land last cultivated, or with the capital last applied to the soil, would always be sold at its *necessary price*, or at that price which is just sufficient to yield the cultivators the common and average rate of profit, or, which is the same thing, to cover the cost of its production. If the price were above this level, then agriculture would be the best of all businesses, and tillage would be immediately extended; if, on the other hand, the price fell below this level, capital would be withdrawn from the soil, and the poorer lands thrown out of cultivation. In such circumstances, it is undeniably certain that no rent could enter into the price of that portion of produce raised with the capital last applied to the soil. Its price is exclusively made up of wages and profits. The proprietors of the superior lands obtain rent; but this is the necessary result of their *greater fertility*. The demand cannot be supplied without cultivating inferior soils; and to enable them to be cultivated, their produce must sell for such a price as will afford the ordinary rate of profit to *their* cultivators. This price will, however, yield a surplus over and above the ordinary rate of profit to the cultivators of the more fertile lands, and *this surplus is rent.*

Origin of Rent.

Progress of Rent.

An increase of rent is not, therefore, as is very generally supposed, occasioned by improvements in agriculture, or by an increase in the fertility of the soil. It results entirely from the necessity of resorting, as population increases, to soils of a *decreasing* degree of fertility. Rent varies in an inverse proportion to the amount of produce obtained by means of the capital and labour employed in cultivation;—that is, *it increases when the profits of agricultural labour diminish, and diminishes when they increase.* Profits are at their maximum in countries like New Holland, Indiana, and Illinois, and generally in all situations in which no rent is paid, and the best lands only cultivated; but it cannot be said that rents have attained their maximum so long as capital yields any surplus in the shape of profit.

A quarter of wheat may be raised in the Vale of Gloucester, or in the Carse of Gowrie, at perhaps a *fourth* or a *fifth* part of the expence necessary to raise it on the worst soils in cultivation. There cannot, however, be at the same time *two or more prices* for the same article in the same market. And it is plain, that if the average market price of wheat be not such as will indemnify the producers of that which is raised on the *worst soils,* they will cease bringing it to market, and the required supplies will no longer be obtained; and it is equally plain, that if the market price of wheat exceeds this sum, fresh capital will be applied to its production, and competition will soon sink prices to their natural level—that is, to such a sum as will just afford *the common and ordinary rate of profit to the raisers of that portion of the required supply of corn which is produced in the most unfavourable circumstances, and with the greatest expence.* It is by the cost of producing this portion that the average price of all the rest must always be regulated. And, therefore, it is plainly all one to the consumers whether, in an advanced stage of society, the excess of return over the cost of production on lands of the first quality belongs to a non-resident landlord, or an occupier. It *must* belong to the one or the other. Corn is not high because a rent is paid, but a rent is paid because corn is high—*because the demand is such that it cannot be supplied without cultivating soils of a diminished degree of fertility, as compared with the best.* Suppose there is an effectual demand for

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10 millions of quarters, and that it is necessary to raise *one* million of these quarters on lands which yield nothing but the common and average rate of profit to their cultivators; it is clear that the relinquishing of the rents payable on the superior lands would be no boon whatever to the cultivators of the inferior lands. It would not lessen their expences; that is, it would not lessen the quantum of capital and labour necessary to produce that portion of the *required supply* which is raised in the most unfavourable circumstances; and, if it did not reduce this expence, it is utterly impossible, supposing the demand not to decline, that it could lower prices. Mr Malthus is, therefore, right in saying, that although landlords were to give up the whole of their rents, their doing so would have no influence on the price of corn. Such an act would only turn farmers into gentlemen, and gentlemen into beggars. The case is, however, distinctly and completely different when the cost of production varies. If it is diminished, the competition of the producers will infallibly sink prices in an equal proportion: If it is increased, no supplies will be brought to market, unless the price be raised to a corresponding level. In no case, therefore, whether the demand be great or small—whether for one or one million of quarters, can the price of raw produce ever permanently exceed or fall below the sum necessary to pay the cost of producing that portion of the supply that is raised on the worst land, or with the last capital laid out on the soil.

Objections to this Theory.

Two objections have been made to this theory. In the *first* place, it has been said that, though it might hold good in a country like New Holland, where land is not appropriated, still it is true that all the lands in every civilized and appropriated country like England, always yield some small rent to the proprietor; and that, therefore, it cannot be said that the price of produce is, in such countries, determined by the cost of raising it on that quality of land which pays no rent.

Mr Mill has justly observed of this objection, that even if it were well-founded, it could not practically affect any of the conclusions we have endeavoured to establish. There are in England and Scotland thousands of acres of land which do not let for L. 20; but to cultivate them would require an outlay of many thousands; and the rent would consequently bear so small a proportion to the expences of production, as to become altogether evanescent and inappreciable. (*Elements of Political Economy*, p. 19, 1st edit.)

Land in every extensive Country which yields no Rent.

There can be no doubt, however, that there is in this, and most other extensive countries, a great deal of land which yields no rent whatever. In the United States and Russia such is unquestionably the case; and yet no one presumes to say that the laws which regulate rent in the United States and Russia are different from those which regulate it in England and France. The poorest lands are always let in immense tracts. If it were attempted to let particular portions of these tracts separately, they would bring no rent whatever; but they appear to yield rent, because rent is paid not for them, but for the more fertile spots intermixed with them. But although it were really true that every rood of land in Britain paid a high rent, it would still be true that such rent did not, and could not, enter into the price of raw produce. The *rent* of a country *consists of the difference, or the value of the difference, between the produce obtained from the capital first applied to the land, and that which is last applied to it.* It would, as we have already shown, be exactly the same thing to the cultivator, whether he paid a rent of ten quarters to a landlord for land yielding, with a certain outlay, 100 quarters of corn, or employed the same capital in cultivating inferior land yielding only 90 quarters, for which he paid no rent. If it were possible always to obtain 100 quarters for every equal additional capital applied to the superior soils, no person, it is obvious, would ever resort to those of inferior fertility. But the fact, that, in the progress of society, new and less fertile land is always brought into cultivation, demonstrates that additional capital and labour cannot be indefinitely applied with the same advantage to the old land. The state of society in any particular country may be such—the demand for agricultural produce may be so great, that every quality of land actually yields rent; but it is the same thing if there be any capital employed on land which yields only the return of stock with its ordinary profits, whether that capital be employed on old or new land. That there is a very large amount of capital employed in such a manner in this and every other country, is abundantly certain. A farmer who rents a farm, besides employing on it such a capital as will, at the existing prices of raw produce, enable him to pay his rent, to obtain the average rate of profit, and to replace his stock previously to the expiration of his lease, will also employ an additional capital, if it will only replace itself, and afford the ordinary rate of profit. Whether he shall employ this additional capital or not, depends entirely on the circumstance of the price of raw produce being such as will repay his expences and profits; for he knows he will have no additional rent to pay. Even at the expiration of his lease, his rent will not be raised; for, if his landlord should require rent, because an additional capital had been employed, he would withdraw it; since, by employing it in agriculture, he got only the same profits he might have got by employing it in any other department of industry. If the capital last applied to the soil yields *more* than the common and average rate of profit, fresh capital will be invested in agriculture, and competition will sink prices to such a level as will just enable them to yield this rate, and no more; if the capital last applied to the soil yields *less* than this common and average rate of profit, it will be withdrawn, until, by the rise of price, the last remaining capital yields this common rate. In every case, therefore, whether the last quality of land taken into cultivation yields rent or not, *the last capital applied to the soil yields only the common and average rate of profit;* and, consequently, the price of the produce which it yields, and which regulates the price of all the rest, is totally unaffected by rent.

Soils not inconsistent with the principle that Rent does not enter into Price.

Payment of Rent on all

It has, in the *second* place, been objected to this account of the nature and causes of rent, that it takes for granted, that, in all extensive countries, landlords permit the farmers of the worst lands to occupy them

Does not suppose that Landlords will allow Farmers to

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without paying any rent. But, it is easy to show that this is a mistake. The price of raw produce is not kept down to its necessary price by the competition of farmers, but by that of the landlords themselves. Though there must necessarily be a very wide difference, in any country of considerable extent, between the best and worst soils, still the gradation from the one extreme to the other is gradual, and almost imperceptible. The best differ but little from those which are immediately inferior to them, and the worst from those immediately above them. And hence it is just as impossible to point out the precise point where the first quality ends and the second begins, or where the second ends and the third begins, as it is to point out the precise point where the contiguous colours of the rainbow differ. Now, suppose that the numbers 1, 2, 3, 4, 5, 6, 7, &c. designate the different qualities of soil in an extensive country, and suppose that the effectual demand for raw produce is such as will just afford the common and average rate of profit to those who cultivate land of the *fifth* degree of fertility, or that represented by No. 5; when such is the case, there can be no doubt that No. 5 will be cultivated; for, besides the peculiar attractions which agriculture possesses, it would be quite as advantageous to cultivate it as to engage in any other business. It would not, however, be more advantageous; for its produce would yield no surplus in the shape of rent. But suppose that a combination took place among the proprietors of Nos. 1, 2, 3, 4, and 5, to withhold a portion of their produce from market; and that, in consequence of this, or any other cause, the price of corn is raised ever so little above the expence of its production on No. 5; in that case, it is obvious that soils of the *very next* degree of fertility, or that that portion of No. 6, which, in point of productive power, differs extremely little from No. 5, would be instantly brought under cultivation; and the increased supply would infallibly sink prices to the level that would just afford the average rate of profit, and no more, to the cultivators of No. 5, or of the poorest soils which the supply of the effectual demand renders it necessary to cultivate. It is quite the same thing, therefore, in so far as price is concerned, whether a country is appropriated or not. When it is appropriated, prices are kept down to their lowest limit by the competition of the landlords. And it is by the self same principle,—the *cost of producing that portion of the necessary supply raised in the most unfavourable circumstances*,—that the price of raw produce is determined in England and France, as it is determined in New Holland and Illinois.

ccupy their ands without paying ent.

Does not account both for a Rise and Fall of Price in the same Way.

But then it is said, that this reasoning involves a contradiction,—that it accounts both for a rise and a fall of price in the same way, or by an extension of cultivation! In point of fact, however, it does no such thing. The market price of corn will always be low where it is cheaply produced, as in Poland; and it will *occasionally* be low where it costs a great deal to produce it, when a redundant supply is brought to market, as is the case in England at this moment. Suppose, as before, that the effectual demand for corn in Great Britain is at present such as will just enable lands of the *fifth* degree of fertility to be cultivated; but that, owing to variable harvests, to injudicious encouragement held out by the Legislature, to the ardour of speculation, to the miscalculation of farmers, or to any other cause, lands of the *sixth* degree of fertility have been cultivated; the increased quantity of produce that must thus be thrown on the market will plainly depress prices to such an extent, that, instead of yielding average profits to the cultivators of No. 6, they will not yield them to the cultivators of No. 5. But they will yield *more* to the cultivators of No. 5 than to those of No. 6; the latter, therefore, will be first driven from their business; and when they have retired, prices will rise, *not* indeed to such a height as to enable No. 6 to be cultivated, but so high as to enable the cultivators of No. 5 to continue their business; that is, as we have already shown, to the precise sum that will enable the raisers of the last portion of the produce necessary to supply the effectual demand to obtain the common and average rate of profit. Should the demand, instead of continuing stationary, increase so that it could not be supplied without cultivating Nos. 6 and 7, the price will have to rise in proportion to the increased expence of cultivating them. But to whatever extent the demand might increase, still, if such an improvement were made in agriculture, or in the art of raising corn, as would enable the supply to be obtained from No. 1 only, the price would necessarily and infallibly fall to the precise sum that paid the expences of its cultivators, and rent would entirely disappear.

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Distinction between Agriculture and Manufactures and Commerce.

This analysis of the nature and causes of rent discovers an important and fundamental distinction between agricultural and commercial and manufacturing industry. In manufactures, the worst machinery is first set in motion, and every day its powers are improved by new inventions; and it is rendered capable of yielding a greater amount of produce with the same expence. And as no limits can be assigned to the quantity of improved machinery that may be introduced—as a million of steam-engines may be constructed for the same, or rather for a less, proportional expence than would be required for the construction of one—the competition of capitalists never fails to reduce the price of manufactured commodities to the sum which the least expensive method of production necessarily requires for their production.

Tendency of Manufactured Products to fall in Price.

Tendency of Agricultural Products to rise in Price.

In agriculture, on the contrary, the best machinery, that is, the *best soils*, are first brought under cultivation, and recourse is afterwards had to inferior soils, requiring a greater expenditure of capital and labour to produce the same supplies. The improvements in the construction of farming implements, and meliorations in agricultural management, which occasionally occur in the progress of society, really reduce the price of raw produce, and, by making less capital yield the same supplies, have a tendency to reduce rent. But, the fall of price which is permanent in manufactures, is only *temporary in agriculture*. A fall in the price of raw produce, by enabling every class to obtain greater quantities than before, in exchange for their products or their labour, raises the rate of profit, and leads, of course, to an increased accumulation of capital. But the

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industry of a nation being always in proportion to the amount of its capital, this accumulation necessarily leads to a greater demand for labour, to higher wages, to an increased population, and, consequently, to a further demand for raw produce and an extended cultivation. Agricultural improvements check for a while the necessity of having recourse to inferior soils and the rise of rents; but the check can only be temporary. The stimulus which they, at the same time, give to population, and the natural tendency of mankind to increase beyond the means of subsistence, is sure, in the end, to raise prices, and by forcing recourse to poor lands, to raise rents.

Earth compared by Mr Malthus to a Series of Machines, endowed with different Productive Powers.

Mr Malthus has, in illustrating this important distinction between agricultural and manufacturing industry, set the doctrine of rent in a clear and striking point of view. "The earth," he observes, "has been sometimes compared to a vast machine, presented by nature to man for the production of food and raw materials; but to make the resemblance more just, as far as they admit of comparison, we should consider the soil as a present to man of a great number of machines, all susceptible of continued improvement by the application of capital to them, but yet of very different original qualities and powers.

"This great inequality in the powers of the machinery employed in procuring raw produce, forms one of the most remarkable features which distinguishes the machinery of the land from the machinery employed in manufactures.

"When a machine in manufactures is invented, which will produce more finished work with less labour and capital than before, if there be no patent, or as soon as the patent is over, a sufficient number of such machines may be made to supply the whole demand, and to supersede entirely the use of all the old machinery. The natural consequence is, that the price is reduced to the price of production from the best machinery, and if the price were to be depressed lower, the whole of the commodity would be withdrawn from the market.

"The machines which produce corn and raw materials, on the contrary, are the gifts of nature, not the works of man; and we find by experience that these gifts have very different qualities and powers. The most fertile lands of a country, those which, like the best machinery in manufactures, yield the greatest products with the least labour and capital, are never found sufficient to supply the effective demand of an increasing population. The price of raw produce, therefore, naturally rises till it becomes sufficiently high to pay the cost of raising it with inferior machines, and by a more expensive process; and, as there cannot be two prices for corn of the same quality, all the other machines, the working of which requires less capital compared with the produce, must *yield rents in proportion to their goodness*.

"Every extensive country may thus be considered as possessing a gradation of machines for the production of corn and raw materials, including in this gradation not only all the various qualities of poor land, of which every large territory has generally an abundance, but the inferior machinery which may be said to be employed when good land is further and further forced for additional produce. As the price of raw produce continues to rise, these inferior machines are successively called into action; and, as the price of raw produce continues to fall, they are successively thrown out of action. The illustration here used serves to show at once the necessity of the actual price of corn to the actual produce, and the different effect which would attend a great reduction in the price of any particular manufacture, and a great reduction in the price of raw produce.

"I have no hesitation, then, in affirming that the reason why the real price of corn is higher and continually rising in countries which are already rich, and still advancing in prosperity and population, is to be found in the necessity of resorting constantly to poorer land—to machines which require a greater expenditure to work them—and which consequently occasion each fresh addition to the raw produce of the country to be purchased at a greater cost;—in short, it is to be found in the important truth that corn *is sold at the price necessary to yield the actual supply; and that, as the production of this supply becomes more and more difficult, the price rises in proportion.*

"I hope to be excused for having dwelt so long, and presented to the reader in various forms the doctrine that corn, in reference to the *quantity actually produced*, is sold at its necessary price like manufactures, because I consider it as a truth of the highest importance, which has been entirely overlooked by the economists, by Dr Smith, and all those writers who have represented raw produce as selling always at a monopoly price."—(*Inquiry into the Nature and Progress of Rent*, p. 37.)

It appears, therefore, that in the earliest stages of society, and when only the best lands are cultivated, no rent is ever paid. The landlords, as such, do not begin to share in the produce of the soil until it becomes necessary to cultivate lands of an inferior degree of fertility, or to apply capital to the superior lands with a diminishing return. Whenever this is the case, rent begins to be paid; and it continues to increase according as cultivation is extended over poorer soils; and diminishes according as these poorer soils are thrown out of cultivation. Rent, therefore, depends exclusively on the extension of tillage. It is high where tillage is widely extended over inferior lands; and low where it is confined to the superior descriptions only. But in no case does rent ever enter into price. For, the produce raised on the poorest lands, or with the capital last applied to the cultivation of the soil, regulates the price of all the rest; and this produce never yields any surplus above the common and average rate of profit.

It being thus established that the circumstance of land being appropriated, and rent paid to the landlords, cannot affect the price of commodities, or make any difference whatever on the principle which regulates their exchangeable value in the earliest stages of society, we proceed, in the next place, to inquire

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into the effects of the accumulation and employment of capital, and of the rise and fall of wages on the value of commodities.

SECT. IV.—*Effect of the Accumulation and Employment of Capital, and of Fluctuations in the Rate of Wages on Exchangeable Value.*

Value of Commodities regulated by the Amount of Immediate Labour and of Capital expended in their Production.

It will be remembered, that the comparative quantities of labour required to produce commodities and to bring them to market, formed, in the early ages of society, and before capital was accumulated, the principle by which their comparative or exchangeable value was regulated. But capital is nothing more than the accumulated produce of *anterior labour;* and when it is employed in the production of commodities, their value must plainly be regulated, not by the quantity of immediate labour only, but by the total quantity of immediate labour and of accumulated labour, or capital, which have been necessarily laid out in their production. Suppose that an individual can by a day's labour, without the assistance of any capital whatever, kill a deer; but that it requires a day's labour to construct weapons necessary to enable him to kill a beaver, and another day's labour to kill it, it is evident, supposing the weapons to have been rendered useless in killing the beaver, that one beaver really took as much labour to kill it as was required to kill two deer, and must, therefore, be worth twice as much. The durability of the weapons, or capital of the beaver hunter, is obviously an element of the greatest importance in estimating the value of the animals killed by him. Had the weapons been more durable than we have supposed,—had they served, for example, to kill twenty beavers instead of one, then it is plain the quantity of labour required to kill a beaver would only have been one twentieth more than the labour required to kill a deer, and the animals would, of course, have been exchanged in that proportion to each other. With every extension of the duration of the weapons, the value of the deer and the beaver would obviously be brought still nearer to equality.

It appears, therefore, inasmuch as capital is nothing but anterior labour, that its accumulation and employment cannot affect the principle which makes the exchangeable value of commodities dependent on the quantities of labour required for their production. A commodity may be altogether produced by capital, without the co-operation of any immediate labour whatever, and, if so, its value in exchange will plainly be regulated by the quantity of capital, that is, of *labour* expended in its production: or it may be partly produced by capital, and partly by immediate labour, and then its exchangeable value will be proportioned to the *sum of the two*, or, which is still the same thing, to the total quantity of labour bestowed upon it. The principles we have now laid down are almost self-evident, and we are not aware that they have been disputed by any political economist of consideration; but a considerable difference of opinion is entertained respecting the effects occasioned by the employment of workmen by capitalists, and by fluctuations in the rate of wages, on value.

The Employment of Workmen by Capitalists does not raise the Price of Commodities.

It does not, however, seem to us that there is much room for these differences. Suppose that a certain quantity of goods, twenty pairs of stockings for example, manufactured by independent workmen, freely exchanged for forty pairs of gloves also manufactured by independent workmen, they would necessarily continue to do so, provided the quantity of labour formerly required for their production continued invariable, after the workmen had been employed by some master manufacturer. In the first case it is true, as Dr Smith has observed, that the whole goods produced by the workmen would belong to themselves, and that, in the second case, they would have to share them with others. But it must be recollected, that in the first case the capital, or accumulated labour, made use of in the production of the commodities, *belonged to the workmen*, and that in the latter case it has been *furnished them by others.* The question then comes to be, Can the circumstance of the labourers voluntarily agreeing to give a portion of the commodities produced by them, as an *equivalent*, or compensation for the advantage and assistance derived from the use of the capital, or labour of others, afford any ground for raising the value of the commodities? It is evident it cannot. The profits of stock are only another name for the *wages of accumulated labour.* They make a part of the price of every commodity in whose production any portion of capital has been wasted. But whether the capital belongs to the labourer himself, or is furnished him by another, is obviously of no consequence. When the capital does not belong to the labourer, the commodities produced by him are divided into *two* specific portions, whereof one is the return for the immediate labour, and the other for the capital, or accumulated labour, expended in producing them. But the aggregate value of the commodities is precisely the same into how many portions soever they may be divided. A shoemaker who manufactures shoes on his own account, must obtain the same rate of profit on their sale, that would accrue to a master shoemaker were he employed by him as a workman. He must not only possess a capital adequate to maintain himself and his family until his shoes can be disposed of, but he must also be able to provide himself with a workshop and tools, to advance money to the tanner to pay his leather, and to provide for various other outgoings. If he did not, exclusive of the ordinary wages of labour, realize a rate of profit, or a compensation for the employment of his capital, equal to the profit obtained by the master shoemaker, it would obviously be for his advantage to lend it to him, and to work on his own account; and it is plain, inasmuch as his shoes could not be sold for a *higher price* than those of the capitalist, that he could not realize a greater rate of profit.

It appears, therefore, that the circumstance of the accumulated labour or capital, and the immediate labour required to produce commodities being furnished by different classes of people, makes no difference whatever on the principle which shows that their exchangeable value depends on the total quantity of labour necessary for their production. It now only

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remains to trace the effects of fluctuations in the rate of wages on price. When we have done this, we shall have exhausted the subject.

Effect of Fluctuations in the Rate of Wages on Exchangeable Value:—

To simplify this inquiry, we shall divide it into two branches. We shall inquire, *first*, whether fluctuations in the rate of wages have any, and what effects on the relative value of commodities produced by the aid of capitals of *equal* degrees of durability; and, *second*, whether these fluctuations have any, and what effects when the capitals employed are of *unequal* degrees of durability.

1st. Effect of these Fluctuations when the Capitals employed in Production are of the *same* degree of Durability.

I. When every class of producers employ either fixed or circulating capitals, of precisely the same degree of durability, they must be all equally affected by a rise or fall of wages. This is a principle which is equally assented to by Mr Ricardo and Mr Malthus, and which is indeed self-evident. But when such is the case, it is plainly impossible that a rise or fall of wages can occasion any variation in the exchangeable, or comparative value of commodities. To revert to our former example, let us suppose that wages, at the rate of one shilling a day, were paid by the stocking manufacturer, one pair of whose stockings exchanged for two pairs of gloves, and that, from some cause or other, the wages of his workmen have been doubled, or raised to two shillings, the question is, could he now obtain a greater quantity of gloves in exchange for his stockings? It is obvious he could not. He could not urge the circumstance of his being obliged to pay a greater amount of wages to his workmen, as a reason why the glove manufacturer should give him more gloves in exchange for his stockings; for, the latter would have it in his power to reply, that *the same rise of wages affected him to precisely the same extent.* If, therefore, one pair of stockings was previously worth two pairs of gloves, they would continue to preserve this relation to each other, so long as the quantities of labour required for their production was not varied, whatever might be the fluctuation of wages—whether they fell to a sixpence, or rose to a guinea a day. Even if the price of commodities rose, which it could not, when wages rose, that would be of no advantage to the producers. Commodities are always bought by commodities, or by labour. Of what consequence, then, could it be to a capitalist, when wages rose, to sell his commodities at an equal advance; when he, in his turn, would be obliged to give so much more for every commodity which he purchased? If wages rise 50 *per cent.* a producer, a farmer, for example, would be precisely in the same condition, whether he sold his corn for 50 *per cent.* advance, and gave an additional 50 *per cent.* as he would be obliged to do, for his hats, shoes, clothes, &c. &c. or sold his corn at its former price, and bought all the commodities which he consumed at the prices he had formerly given for them.

In order farther to illustrate this principle, we may be allowed to make a supposition, which, although it can never actually take place, will serve to set our doctrine in a clearer point of view. Should the quantities of labour required for the production of every species of commodities be increased in exactly the same proportion, it is plain their exchangeable values would remain unaltered. Their real price would, however, be augmented. A bushel of corn would not then exchange for a greater quantity of muslins or of broad cloth, than it did before the increased expence of its production; but each would be the produce of a greater quantity of labour. In such circumstances, the prices of commodities would remain stationary, while the wealth and comforts of the society would be materially diminished. Every person would have to make greater exertions to obtain a given quantity of any one commodity; but as the expence of producing *all* commodities is, by the supposition, equally increased, it would not be necessary to make any greater exertions to obtain one than another, and their comparative values would be totally unaffected.

But, if a general and equal increase of the quantity of labour required for the production of commodities could not alter their relative values to one another, how is that to be effected by a general and equal increase of the wages paid for that labour? The thing is obviously impossible. If a beaver exchanged for a deer, when wages were at one shilling a day, it must do the same when they are increased to two shillings, or ten shillings, or twenty shillings. However high wages might be raised, the market-price of the beaver and deer would continue unchanged. After wages had been raised, the value of the deer would be differently divided—a *greater* share would belong to the labourer, and a *less* to the capitalist; but that would be the only effect produced. The real price of the commodities would not be in the least influenced by this rise of wages. The quantity of labour required for their production would not be increased; and it would, therefore, be equally easy to obtain them.

2d. Effect of these Fluctuations when the Capitals employed in Production are of *different* degrees of Durability.

II. We have seen by the investigation under the preceding head, that, where the fixed or circulating capitals employed in the production of commodities are of *equal* degrees of durability, fluctuations in the rate of wages affect all classes of producers to the same extent, and have, therefore, no influence on the exchangeable value of commodities, or on their price. But when the capitals employed are of *different* degrees of durability, this is not the case. Fluctuations in the rate of wages cannot, in such circumstances, equally affect every class of producers, and the natural and indestructible equilibrium of profit could not be maintained without a variation in the relative value of their products. To illustrate this, let us suppose, that a certain quantity of goods, the produce of fixed capital or machinery fitted to last many years, freely exchange for a certain quantity of other goods entirely produced by manual labour. It is plain they could not continue to be exchanged on this footing, after a rise or fall of wages. For the proprietor of the machinery would be very little affected by such fluctuations, while the proprietor of the goods produced by manual labour would be very seriously affected by them. And, therefore, when wages fluctuate, the relative values of the goods produced by capitals of different degrees of durability must also fluctuate—that is, they must be adjusted so that they may still continue to yield the same common and average rate

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of profit. Let us now endeavour to trace the mode in which this adjustment is effected.

The arguments we have brought forward, to show the impossibility of fluctuations in the rate of wages, affecting the exchangeable value of commodities produced by capitals of the same durability, were first advanced by Mr Ricardo. He, too, was the first who endeavoured to analyse and discover the precise effects of fluctuations in the rate of wages on commodities, when the capitals employed in their production were *not* of the same degree of durability. The results of his researches in this most difficult branch of the science were still more important, and more completely at variance with the universally received opinions of political economists. Mr Ricardo not only showed that it was impossible for any rise of wages to raise the price of *all* commodities; but he also showed, that in many cases a rise of wages necessarily led to a *fall* of prices, and a fall of wages to a *rise* of prices! The novelty of these opinions, and the talent and ingenuity with which they were supported, immediately recommended them to general notice; and the repeated examinations to which they have been subjected have served to confirm their truth, and to set them in a still clearer point of view. Some of the subordinate doctrines respecting value advanced by Mr Ricardo in the first and second editions of his *Principles of Political Economy and Taxation*, were opposed by Mr Malthus in his recent publication. But Mr Malthus does not attempt to invalidate the leading principles established by Mr Ricardo; and the alterations and corrections which the latter has made in the third edition of his work, have gone far to remove the objections of Mr Malthus.

If a Rise of Wages lowers Profits, it must lower the Value of Goods chiefly produced by Fixed Capital or Machinery.

Suppose a manufacturer has a machine worth L. 20,000, of a high degree of durability, and which can, without the assistance of any manual labour, produce commodities. If profits were at 10 *per cent.*, the commodities produced by this machine would sell for L. 2000, together with a very small addition to replace its wear and tear. * Now, it is quite certain, that if, from any cause whatever, profits either rise or fall, the price of the goods produced by this machine would also rise or fall.—(Malthus's *Principles of Political Economy*, p. 92.) If profits were to rise to 15 *per cent.*, the price of the goods produced by the machine must, in order that its owner may obtain the same profit with other capitalists, rise to L. 3000; and if, on the other hand, profits fall to five *per cent.*, the price of his goods must, for the same reason, fall to L. 1000. If, therefore, it can be shown that a rise of wages reduces the rate of profits, it is plain it must also reduce the exchangeable value, or price, of all such commodities as are chiefly produced by machinery, or fixed capital of a considerable degree of durability, or by circulating capital returnable at distant periods, and *vice versa*. But it is not difficult to show that this is really the case, and that, in point of fact, profits always fall when wages rise, and rise when wages fall.

It is plain, from what has been previously stated, that to whatever extent wages might rise, it would be impossible for the producers of any species of commodities, whether the capitals employed in their production were returnable in a day, or week, or any other period, to obtain a larger share of the commodities produced by others of the *same class*,—that is, whose capitals were returnable in *equal periods* with their own. Suppose wages rise ten or twenty *per cent.*, that would not enable the holder of a capital returnable every month, or every twelve months, to obtain any additional value in exchange for his commodities from such of his fellow capitalists as were affected to precisely the same extent with himself by the rise of wages,—that is, whose capitals were returnable in the very same period as his own. This is as absolutely impossible as it is to change the relation of proportional numbers by multiplying or dividing them all by the same number; and, therefore, it cannot be true that a rise of wages will raise the price of any one commodity, as compared with all other commodities.

But, if a rise of wages cannot do this, it is demonstrably certain it must lower profits. Let us suppose that the numbers 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, represent capitals of corresponding degrees of durability. When wages fluctuate, the proprietors of the least durable capitals, numbers 1, 2, 3, 4, and 5, are plainly more affected thereby than the proprietors of the more durable capitals, numbers 6, 7, 8, 9, and 10. Let us suppose that wages rise, and let us endeavour to discover what would be the effect of this rise on the holder of a capital of the *tenth* degree of durability. We have already shown that whatever might be the amount of the rise—whether it were 1, 10, or 100 *per cent.*, the holder of such a capital could not possibly obtain any additional quantity of the commodities belonging to other producers whose capitals were also of the *tenth* degree of durability; and in so far, therefore, as this class of commodities is concerned, profits will be reduced to the precise extent that wages have risen. But the holders of the other capitals are all of them *more* affected by the rise of wages than the holders of No. 10; and if we took either of them as a standard by which to measure profits, they would appear to have fallen in a still greater proportion.

Profits vary inversely as Wages.

It is absolutely certain, therefore, that *profits vary inversely as wages*,—that is, *they fall when wages rise, and rise when wages fall.* But owing to the different and ever varying proportions in which fixed and circulating capital and immediate labour are employed in the production of commodities, it is extremely difficult to discover the precise extent to which any given fluctuation in the rate of wages af-

* So small a sum as two shillings and elevenpence would be sufficient for this purpose, if the machine would last for 100 years; for an annuity of two shillings and elevenpence accumulating for 100 years at 10 *per cent.*, would, at the end of that period, amount to L. 20,000.

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fects profits. We shall, however, state three different cases which will briefly, and, we hope, satisfactorily, elucidate the manner in which fluctuations in the rate of wages always operate, and the method to be followed in estimating their influence on profits.

Method of estimating the Effects of Fluctuations in the Rate of Wages on Profits.

1. If all commodities were produced by immediate labour, or by capital employed in the payment of wages, it is obvious that every rise of wages would cause an equal fall of profits. A capitalist who employed L. 1000 in the payment of wages, must, if profits were at 10 *per cent.*, sell the commodities for L. 1100. But when wages rise 5 *per cent.*, or to L. 1050, he would not be able to sell his commodities for more than L. 1100; *for money is itself a commodity, and as, by the supposition, all commodities are produced by immediate labour, the rise of wages would affect the producers of money in the very same degree that it affected all other producers.* In this case, therefore, it is plain every rise of wages will equally sink profits, and every fall of wages will equally raise them.

2. If all commodities were produced, *one-half* by immediate labour, and the *other half* by capital, profits would only fall to half the extent that wages rose. Suppose a capitalist employs L. 500 in the payment of wages, and L. 500 as a fixed capital, when profits are at 10 *per cent.*, the commodities produced must, as before, sell for L. 1100. If wages rose 5 *per cent.*, the capitalist would have to pay L. 525 as wages, and would, consequently, only retain L. 75 as profits. In this case, therefore, a rise of wages to the extent of 5 *per cent.* would, because of the employment of equal quantities of capital and immediate labour in the production of commodities, only sink profits $2\frac{1}{2}$ *per cent.*

3. If *all* commodities were produced by capital of a high degree of durability, the capitalists, it is obvious, would not be at all affected by a rise of wages, and profits would, of course, continue as before.

Now, suppose that commodities, instead of being wholly produced either by immediate labour, as in the first case, or wholly by equal quantities of immediate labour and of capital, as in the second, or wholly by fixed capital as in the third, are partly produced in the one mode and partly in the other, and let us see what effect this increase of 5 *per cent.* in the rate of wages would have on their relative values. To facilitate this inquiry, we shall distinguish these three descriptions of commodities by the Nos. 1, 2, and 3. Now, it is quite evident that the rise of wages has affected No. 1 $2\frac{1}{2}$ *per cent.* more than it has affected No. 2, and 5 *per cent.* more than it has affected No. 3. No. 1 must, therefore, as compared with No. 2, have risen $2\frac{1}{2}$ *per cent.* in exchangeable value, and as compared with No. 3, it must have risen 5 *per cent.*; No. 2 must have fallen $2\frac{1}{2}$ *per cent.* as compared with No. 1, and risen $2\frac{1}{2}$ *per cent.* as compared with No. 3; and No. 3 must have fallen 5 *per cent.* as compared with No. 1, and $2\frac{1}{2}$ *per cent.* as compared with No. 2. If wages, instead of rising, had fallen, the same effects would obviously have been produced, but in a reversed order. The proprietors of the commodities of the class No. 1 would gain 5 *per cent.* by the fall; those of No. 2 would gain $2\frac{1}{2}$ *per cent.*, and those of No. 3 nothing; and the relative values of these commodities would be adjusted accordingly. *

General Rule on the subject of all Fluctuations.

Thus, then, it appears, inasmuch as any commodity taken for a standard by which to estimate the relative values of other commodities, must itself be produced by capital returnable in a certain period, that *when wages rise, all commodities produced by* LESS *durable capitals than those which produce the commodity taken for a standard, will rise in exchangeable value, and all those produced by* MORE *durable capitals will fall; and conversely when wages are reduced.* Suppose, as before, that the Nos. 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10, represent capitals of corresponding degrees of durability. If a commodity produced by the least durable capital, No. 1, and which may be supposed to be wholly employed in the payment of wages, be taken for a standard, all commodities whatever produced by the other and more durable capitals would *fall* in value when wages rose; and if we suppose those produced by No. 2 to decline 1 *per cent.*, those produced by No. 3 would decline 2 *per cent.*, those produced by No. 4 3 *per cent.*, and so on until we arrive at No. 10, which will have fallen 9 *per cent.* If, on the other hand, a commodity produced by the most durable capital, No. 10, and which may be supposed to consist wholly of highly durable machinery, be made the standard, when wages rise all the commodities produced by the other less durable capitals would also rise; and if those produced by No. 9 rose 1 *per cent.*, those produced by No. 8 would rise 2 *per cent.*, and those produced by No. 1 9 *per cent.* If a commodity produced by capital of a *medium* degree of durability, as No. 5, and which may be supposed to consist half of circulating capital employed in the payment of wages, and half of fixed capital or machinery, be taken as a standard, the commodities produced by the less durable capitals, Nos. 4, 3, 2, and 1, will *rise* with a rise of wages, on the former hypothesis, the first, or No. 4, 1 *per cent.*, the second, or No. 3, 2 *per cent.*, &c.; while those produced by the more durable capitals, Nos. 6, 7, 8, 9, and 10, will *fall*, the first, or No. 6, 1 *per cent.*, the second, or No. 7, 2 *per cent.*, &c. exactly the reverse of the other.

Hence it is obvious that the effect which variations in the rate of wages have on *price* will principally depend on the nature of the capital employed in the production of gold and silver. Whatever may be the proportions of circulating capital appropriated to the payment of wages, and of fixed capital employed in the production of the material of which money is made, all those commodities which are produced by the agency of a greater quantity of labour and with less fixed capital or machinery, will rise when wages rise, and fall when wages fall; but those that are produced by the agency of a less quantity of la-

* The examples we have here given are substantially the same with those given by Mr Mill. See his valuable work entitled *Elements of Political Economy*, p. 77.

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bour, and with more fixed capital or machinery, will fall when wages rise, and rise when wages fall; and those that are produced in nearly the same circumstances, or by the agency of the same quantities of circulating and fixed capital as money, will not be affected by the fluctuations of wages.

Variations of Exchangeable Value caused by Fluctuations in the Rate of Wages confined within narrow limits.

It should, however, be observed that the variations in the exchangeable value of commodities caused by variations in the rate of wages, are confined within very narrow limits, and can hardly, in any circumstances, exceed 6 or 7 *per cent.** There can be no rise of wages without a fall of profits. The produce of the land, or rather of the capital which pays no rent, and which governs the price of all the rest, is divided between the farmer and the labourer, and the more that is given to the latter, the less will plainly remain for the former. The same is the case in every other department of industry. Whenever, therefore, wages rise, profits necessarily and unavoidably fall; and this fall not only checks the rise that would otherwise take place in the price of the goods produced by less durable capitals than the medium in which price is estimated; but it also checks the fall that would take place in the price of the goods produced by more durable capitals. To exemplify this, let us suppose a manufacturer employs a capital of L. 10,000, one-half being employed as machinery, and the other half as a circulating capital appropriated to the payment of wages. If profits are at 10 *per cent.*, the goods produced by the manufacturer must sell for L. 11,000. Now, suppose wages to rise one *per cent.*, if the price of the goods were proportionably increased, they would have to sell for L. 11,050. But they would not be proportionably increased; for every rise of wages must lower profits. Suppose, then, that profits are reduced ½ *per cent.*, the goods will still sell for L. 11,000, the increase of L. 50 caused by the rise of wages, being just equivalent to the fall of L. 50 caused by the reduction of profits. Although, therefore, a rise of wages has a necessary tendency to raise the exchangeable value of one class of commodities, and to lower that of another class, the fall of profits, which must inevitably follow every rise of wages, has a different effect, and tends to sink the price of the commodities which the increase in the rate of wages would raise, and to elevate the price of those which the same increase would sink. In the great majority of cases, these opposite effects mutually balance each other; and prices continue nearly the same, after a fall or rise of wages, as before.

"This is not the case with the other great cause of variations in the value of commodities, namely, the increase or diminution in the quantity of labour necessary to produce them. An alteration in the permanent rate of profits, to any great amount, is the effect of causes which do not operate but in the course of years; whereas alterations in the quantity of labour necessary to produce commodities are of daily occurrence. Every improvement in machinery, in tools, in building, in raising the raw material, saves labour, and enables us to produce the commodity to which the improvement is applied with more facility, and, consequently, its value alters. In estimating, then, the causes of the variation in the value of commodities, although it would be wrong wholly to omit the consideration of the effect produced by a rise or fall of labour, it would be equally incorrect to attach much importance to it; and, consequently, in the subsequent part of this work, though I shall occasionally refer to this cause of variation, I shall consider all the great variations which take place in the relative value of commodities to be produced by the greater or less quantity of labour which may be required to produce them." (Ricardo, *Principles*, &c. p. 33.)

Variations in the Rate of Money Wages cause of the Popular Opinion.

The universally received opinions respecting the effect of a rise of wages on the price of commodities have obviously originated from a rise in the *money* price of commodities being almost always confounded with a rise in their *real* price. But these two things are totally distinct. *Real wages*, as we shall afterwards show, *depend on the proportion of the produce of industry which belongs to the labourer*. They are high when this proportion is large, and they are low when it is small. It is to real wages that we always refer. And it is plain, that every inference respecting the rate of real wages, drawn from fluctuations in the rate of money wages at different periods, must be completely erroneous, if we have not estimated such money wages with reference to the relative values of money and commodities at the time when the fluctuations took place. The money wages of labour may be raised from 1s. to 2s. or 5s. a-day; and the real wages of labour may, notwithstanding, be all the while diminishing. This has been actually the case in Britain during the last thirty-five years. Money wages were in 1810 double what they had been in 1790; but, as the exchangeable value of our currency had, in the interval, been more than proportionably reduced, the price of commodities rose still faster than wages; and the proportion of the produce of industry belonging to the labourers, or their real wages, was consequently diminished. In such a case, to ascribe the rise of prices to the rise of wages would be evidently absurd. In no case, however, will it be found that a rise of real wages will raise the price of *all* commodities. A large class will remain stationary, after wages rise; another class will rise a little; and another class will fall a little. All considerable variations in the relative value of commodities are the consequence of variations in the quantity of labour required for their production, and not of variations in the rate at which that labour is paid.

Exchangeable Value of Commodities does not depend on the Quantity of Capital employed in their Production.

Colonel Torrens contends, in his late valuable work on the *Production of Wealth*, in opposition to the theory we have now endeavoured to establish, that after capital has been accumulated, the relative, or exchangeable value of commodities, is no longer, as in the early stages of society, determined by the total quantities of labour required to bring them to

* Ricardo *On the Principles of Political Economy and Taxation*, 3d edit. p. 33.

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market, but by the quantities of capital expended on their production. At bottom, however, this theory is precisely the same with that which we have just explained. Capital is nothing but immediate labour accumulated; and to say that the exchangeable value of commodities depends on the quantity of it employed in their production, is only another way of expressing the identical proposition we have illustrated. Colonel Torrens, however, and those who agree with him, contend that the difference between the two theories is not apparent but real. "If," say they, "two capitalists employ *equal* stocks, the one in paying the wages of masons employed to build a house, and the other in purchasing wine after it has been put into casks, and keeping it until it has become fit for use, then, as the products of equal capitals must always be equal, the house and the wine will be worth precisely the same sum, though it is plain they are produced by very different quantities of labour." This case is very ingeniously put; and it deserves attention from the opportunity which it affords of explaining a point respecting which there has been a great deal of misconception. At first sight, it certainly seems as if *both* accumulated labour and immediate labour had been employed in the construction of the house, and accumulated labour only in the production of the wine. But, in point of fact, all that is done in either case is, to *change the form of equal capitals;* to transmute, if we may so speak, a certain quantity of capital, through the medium of human hands, into a house; and to transmute the same quantity of stock, through the medium of natural powers, into wine fit for drinking. The capital which is consumed by the mason in food and clothes is plainly not expended on the house, but on *himself;* and it is his immediate labour only, or the exertion of his physical powers, that forms the only labour really expended on the house. The employer of the mason paid him his wages, *not*, as Colonel Torrens supposes, in the unreasonable expectation, that he would lay out these wages, in addition to the labour of his hands, on his house, but that he might lay out the wages on himself, and give him his labour *as an equivalent* for them. The object which the builder of the house had really in view was, to convert a certain amount of capital into a house, and to accomplish this object, it was necessary that the capital should, in the first place, be exchanged for, or converted into, the immediate labour of masons. In the production of the wine, this species of transmutation was not necessary; the effect which had, in the first case, been produced by the agency of men, being, in the second case, produced by the agency of the processes which Nature herself carried on in the casks. It is clear, therefore, that no greater quantity of labour was required to produce the house than to produce the wine. Different *agents* were employed to convert the capital into the finished commodities, but that was all. The quantity of capital which set these agents in motion was, in both cases, exactly the *same*, and, consequently, both products were brought into existence by the same quantity of labour.

The error into which Colonel Torrens has fallen, shows the necessity, in estimating the cost of commodities, of always separating between the capital, or accumulated labour, expended in the payment of wages, and the immediate labour which that capital employs. The *sum* of these two really amounts to *twice* the quantity of labour actually expended on the commodities. The capital given as wages to the labourer is merely the price, or equivalent of his labour; and the cost of producing the commodity must, therefore, be determined by the amount of wages, or of immediate labour given for these wages, taken *singly* and not together. When fixed capital is used, the cost of the commodity depends, as we have already shown, on the quantity of immediate labour, or circulating capital, and of fixed capital, necessarily expended on their production.

No one can fail to observe how naturally and beautifully these conclusions harmonise with the principles we endeavoured to establish when treating of the production of wealth. We there showed that no commodity which it did not require some portion of labour to appropriate or produce, could be possessed of exchangeable value, or become wealth; and that every diminution of the quantity of labour required to produce commodities, lowered their exchangeable value, and made them more easily obtainable by all classes: And the analysis we have now completed shows, that labour is not only essential to the existence of exchangeable value, but that it is in every stage of society, from the rudest to the most improved, *the single and only principle which enters into its composition.* *

Sect. V.—*Profits and Wages vary inversely—Accumulation of Capital not the Cause of a Fall of Profits—The Increasing Sterility of the Soil shown to be the Chief Cause of a Rise of Wages, and consequently of a Fall of Profits—Distinction between Absolute and Proportional Wages.*

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Having shown in the previous sections, that no part of the produce of the capital last applied to the cultivation of the land, and which regulates the price

* Sir William Petty had stated, so early as 1667, that the value of commodities is always regulated by the quantity of labour required to produce them; but there is the same difference between his statements and the analysis and investigations of Mr Ricardo, whom we have followed in this section, that there is between the conjectures of Pythagoras respecting the true system of the world and the demonstrations of Newton. The statement of Sir William Petty is however curious, and we subjoin it:

"If," says he, "a man can bring to London an ounce of silver out of the earth in Peru in the same time that he can produce a bushel of corn, then one is the natural price of the other; *now, if, by reason of new and more easie mines, a man can get two ounces of silver as easily as formerly he did one, then corn will be as cheap at 10s. the bushel as it was before at 5s. cæteris paribus.*" (*Treatise of Taxes and Contributions,* ed. 1679, p. 31.)

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of all the rest, goes to the landlord as rent, but that it is exclusively divided between the capitalist and the labourer; and having also shown that a rise of wages does not raise the value of commodities, it follows necessarily and directly that *profits must vary inversely as wages, that is, they must fall as wages rise, and rise as wages fall.* The limits to which this article has already extended, prevent our entering into an investigation of the various circumstances which determine the market rate of wages. It is sufficient to remark, that it can never, for any considerable period, fall below such a sum as is required to support the existing labourers, and to enable them to continue their race. This is termed by Dr Smith and Mr Ricardo the *necessary* rate of wages, and forms a limit below which it is quite impossible they can be permanently reduced. But as the subsistence of the labourer must always principally consist of raw produce; and as, owing to the necessity of resorting to superior soils as society advances, its price has a constant tendency to rise, the *necessary* rate of wages must have the same tendency. Agreeably to this theory, therefore, we should expect, that in all newly settled countries, and where none but the best soils are cultivated, profits would be high; and that in all old settled and densely peopled countries, and where soils of a very inferior quality are cultivated, profits would be comparatively low—and such we find to be really the case.

We might here take leave of this part of our subject; but as the theory we have deduced from the conclusions in our previous sections is very different from the common one, we shall endeavour to set it in a still clearer point of view.

Opinion of Dr Smith, &c.

Dr Smith was of opinion, that the rate of profit varied inversely as the amount of capital, or, in other words, that it was always greatest where capital was least abundant, and lowest where capital was most abundant. He supposed, that, according as capital increased, the principle of competition would stimulate capitalists to endeavour to encroach on the employments of each other; and that, in furtherance of their object they would be tempted to offer their goods at a lower price, and to give higher wages to their workmen. (*Wealth of Nations*, Vol. II. p. 38.) This theory was long universally assented to. It has been espoused by MM. Say, Sismondi, and Storch, by the Marquis Garnier, and, with some slight modifications, by Mr Malthus. But, notwithstanding the deference due to these authorities, it is easy to see that the principle of competition could never be productive of a general fall in the rate of profit. Competition will prevent any one individual from obtaining a higher rate of profit than his neighbours; but no one will say that competition diminishes the *productiveness of industry*, and it is on this that the rate of profit must always depend. The fall of profits which invariably takes place, as society advances, and population becomes denser, is not owing to competition, but to a very different cause—to A DIMINUTION OF THE POWER TO EMPLOY CAPITAL WITH ADVANTAGE, *resulting either from a decrease in the fertility of the soil, which must be taken into cultivation in the progress of society, or from an increase of taxation.*

Error of this Opinion.

The Decreasing Fertility of the Soil Principal Cause of a Fall of Profits.

Mr Malthus has demonstrated, that population has a constant tendency not only to equal, but to *exceed* the means of subsistence. But if the supply of labourers be always increased in proportion to every increase in the demand for their labour, it is plain the mere accumulation of capital could never sink profits by raising wages—that is, *by increasing the labourer's share of the commodities produced by him.* It is true, a sudden increase of capital would, by causing an *unusually* great demand for labourers, raise wages, and lower profits: but such a rise of wages could not be permanent; for the additional stimulus it would give to the principle of population would, as Mr Malthus has shown, by proportioning the supply of labour to the increased demand, infallibly reduce wages to their former level. If, therefore, it were possible always to employ additional capital in the raising of raw produce, in the manufacturing of that raw produce when raised, and in the conveying of the raw and manufactured products from place to place, with an equal return, it is evident, supposing taxation to continue invariable, that no conceivable increase of the national capital could occasion the slightest fall in the rate of profit. So long as labour is obtainable at the same rate, and so long as the productive power of that labour is not diminished, so long *must* the profits of stock continue unaffected. Assuming, then, that the mere increase of capital has no lasting effect on wages, it must obviously be the same thing, in so far as the rate of profit is concerned, whether ten or ten thousand millions be employed in the cultivation of the soil, in the manufactures and commerce of this, or any other kingdom; provided the last million so employed be as productive, or yields as large a return as the first. But such is always the case with the capital employed in manufactures and commerce. The greatest possible amount of capital and labour may be employed in fitting and adapting raw produce to our use, and in transporting it from where it is produced to where it is to be consumed, without a diminished return. If a given quantity of labour will now build a ship of a given burden, or construct a machine of a given power, it is certain that an equal quantity of labour will at any future period be able to build a similar ship, or to construct a similar machine; and it is also certain, that although these ships and machines were indefinitely increased, the last would be equally well adapted for every useful purpose, and equally serviceable as the first. The probability, indeed, or rather, we should say, the certainty is, that the last would be much more serviceable than the first. No possible limit can be assigned to the powers and resources of genius, to the improvement of machinery, and of the skill and industry of the labourer. Future Watts, Arkwrights, and Wedgewoods, will arise; and the stupendous discoveries of the last and present age will doubtless be equalled, and perhaps surpassed, in those which are to come. It is, therefore, clear to demonstration, that if equal quantities of capital and labour could always raise *equal quantities of raw produce*, the utmost additions to the capital

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of the nation could never diminish the capacity to employ that capital with advantage, or sink the rate of profit. But here, and here only, the bounty of Nature is limited, and she deals out her gifts with a frugal and parsimonious hand.

——— Pater ipse colendi
Haud facilem esse viam voluit——

Equal quantities of capital and labour do not always obtain equal quantities of raw produce. In raising it, man has to contend with constantly increasing difficulties. The soil is of limited extent, and of still more limited fertility. In every advancing country, the most fertile lands are, as we have already seen, speedily brought under cultivation, and recourse must then be had to lands of a less degree of fertility, or which yield *less* produce in return for the same expenditure. It is this limited fertility of the soil that is the real cause of a fall of profits. It is utterly impossible to go on increasing the price of that raw produce, which forms the principal part of the subsistence of the labourer, by taking inferior soils into cultivation, without also increasing his wages. A rise of wages is seldom or never exactly coincident with a rise in the price of necessaries, but they can never be very far separated. The price of the necessaries of life is, in fact, the cost of producing labour. The labourer cannot work if he is not supplied with the means of subsistence. And although a certain period of varying extent, according to the circumstances of the country at the time, must always elapse, when necessaries are rising in price, before wages can be proportionably augmented, there can be no question but that, in the end, such an augmentation will be brought about. Now, as rent is nothing but the excess, or the value of the excess, of the produce obtained from the best above that obtained from the very worst soils in cultivation, it is plain it does not enter into the cost of production, and can have no influence whatever on prices. Still better to elucidate this fundamental principle, let us suppose that an individual has two loaves on his table; one raised on very fertile land, the other on the very worst land in cultivation: in the latter, there will be no rent, and it will be wholly divided between wages and profits. We have already shown that it is the cost of producing this loaf which will regulate the price of all other loaves; and although it will be true that the rent which the loaf raised on the best land will afford will be equal to all the difference between the expence of growing the corn of which it is made, and the corn raised on the worst lands of which the standard loaf is made, yet it is only in consequence of this difference that any rent whatever is paid. Twenty different loaves, all selling for the same price, may yield different portions of rent; but it is one only, that which yields no rent, which regulates the value of the rest, and which is to be considered as the standard. It is demonstrable, therefore, that rent does not enter into price. Wages and profits make up the whole value of every commodity. And, therefore, when wages rise, profits must fall; and when wages fall, profits must rise. But we have shown that there is never any falling off, but a constant increase, in the productiveness of the labour employed in manufacturing and preparing raw produce. And such being the case, it is demonstrably certain, that the subsistence of the labourer could never be increased in price, and consequently that no additions could ever be made to his *necessary* wages, were it not for the diminished power of agricultural labour, originating in the inevitable necessity under which we are placed, of *resorting to poorer soils to obtain raw produce as society advances.* The *constantly decreasing fertility of the soil* is, therefore, at bottom, the great and permanent cause of a fall of profits. Profits would never fall if wages were not increased; and, supposing taxation to continue invariable, wages would never be increased were it not for the decreasing fertility of the soil, and the consequent increase of the labour necessary to obtain corn and other raw products.

"With a permanently high price of corn," says Mr Ricardo, "caused by increased labour on the land, wages would be high; and, as commodities would not rise on account of the rise of wages, profits would necessarily fall. If goods worth L. 1000 require at one time labour which cost L. 800, and at another time the price of the same quantity of labour is raised to L. 900, profits will fall from L. 200 to L. 100. Profits would not fall in one trade only, but in all. High wages equally affect the profits of the farmer, the manufacturer, and the merchant. There is no other way of keeping profits up but by keeping wages down."—(*On Protection to Agriculture*, p. 43.)

Profits depend on Proportional Wages.

It is necessary, however, to observe, that although profits depend on wages, they do not depend on wages estimated in money, in corn, or any other commodity, but on PROPORTIONAL *wages, that is, on the share of the commodities produced by the labourer, or of their value, which is given to him.* It is, indeed, easy to see that proportional wages may be increased, at the same time that wages, if estimated in corn, or any other necessary, would be found to be diminished; and, in point of fact, such is almost uniformly found to be the case when recourse is had to poor soils. Suppose that the produce obtained from a given amount of capital applied to the land last taken into cultivation in America yields 100 quarters, the labourer will perhaps receive 60 quarters, or 60 *per cent.* of the produce as his wages. But the same amount of capital, if applied to the land last taken into cultivation in Britain, would not yield more than 50 quarters; and supposing the labourer to get only 40 quarters, or 20 quarters less than in America, still his *proportional* wages, or the wages which determine the rate of profit, would be 80 *per cent.* or 20 *per cent.* higher than in America. In the early stages of society, and wherever the best lands only are cultivated, proportional wages are always low, and profits high; but these low proportional wages are always the most advantageous to the labourer, because, as labour is, in such circumstances, extremely productive, a small per-centage of its total amount gives a large supply of necessaries and conveniencies. In the advanced stages of society, on the other hand, and wherever lands of a very inferior degree of fertility are cultivated, proportional wages are high and profits low; but owing to the increased difficulty of pro-

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duction, these high proportional wages afford only a comparatively small supply of necessaries and conveniencies.

It is therefore on *proportional* wages that profits must always depend; and owing to the increasing difficulty of producing corn and other products, such proportional wages always increase as society advances. This natural tendency of profits to fall is occasionally checked by improvements in machinery, and by discoveries in agriculture; but the effects of these improvements are only temporary; for, by stimulating population, they never fail, in the long run, to force recourse to poor soils; and whenever this is the case, *profits must unavoidably fall.*

It has been contended, that both wages and profits are high in America, and that, therefore, the theory which we now have been endeavouring to explain, and which makes profits in every case to depend on wages, must be erroneous. But the remarks we have just made show that this objection is totally unfounded. It is by proportional quantities, and not by absolute quantities, that we are to estimate the effect of wages on profits. The American labourer receives a less proportion of the produce raised by him than the British labourer, and profits are consequently high in America; but as the American labourer cultivates none but the best soils, and which yield a very large produce, his smaller share of this large aggregate produce gives him a great absolute quantity of necessaries and conveniences, and his condition is, therefore, comparatively prosperous.

An Increase of Taxation Reduces Profits.

We have, throughout this discussion, been supposing taxation to be invariable. It is plain, however, that as soon as it is increased, it must have one or other of two effects—it must either lower the labourer's command over necessaries and luxuries, and degrade his condition, or it must fall on profits. There are limits, however, and those not very difficult to be attained, to the power of the labourers to pay taxes; and whenever these limits have been reached, they must entirely fall on profits. It has, therefore, been most justly and truly observed by Dr Smith, that a heavy taxation has exactly the same effects as an increased barrenness of the soil, and an increased inclemency of the heavens.

Errors of Sir J. Child and Dr Smith with respect to the Low Rate of Profit in Holland.

The great wealth and commercial prosperity of Holland has been confidently appealed to by Sir Josiah Child, and others, as a convincing proof of the superior advantages of low profits and interest; and seems also to have led Dr Smith to suppose that the mere accumulation of capital could sink the rate of profit. But in this instance, there can be no doubt that Sir Josiah Child mistook *the effect of heavy taxation* for the *cause of wealth,* and that Dr Smith mistook the same effect for the *effect of the accumulation of capital.* A country, whose average rate of profit is considerably less than the average rate of profit in surrounding countries, may, notwithstanding, abound in wealth, and be possessed of immense capital; but it is the height of error to suppose, that this lowness of profit could have facilitated their accumulation. There is unquestionable evidence to show that the capital of Holland had been chiefly amassed when profits were comparatively high; and that the subsequent fall of profits was almost entirely a consequence of the oppressiveness of taxation, and the continued increase of the public debt. In 1580, the interest of the public debt of the province of Holland amounted to 117,000 florins, but so rapidly did it increase, that in 1655, during the administration of the famous John de Witt, the states were compelled to reduce the interest of the debt from 5 to 4 *per cent.*; and yet, notwithstanding this reduction, it amounted, in 1678, to 7,107,128 florins! (Metelerkamp, *Statistique de la Hollande*, p. 203.) It was this enormous increase of the public debt, and the proportionable increase of taxation which it occasioned, and not the accumulation of capital, that was the real and sole cause of the fall of profits in Holland, and ultimately of her decline and ruin. Sir William Temple, in his *Observations on the United Provinces,* mentions that the trade of Holland was on the decline in 1668, the period when Sir Josiah Child's *Treatise* was first published; and he farther states, that the vast capitals of the Dutch merchants had been chiefly accumulated previously to the war in which the Republic had been engaged with Cromwell and Charles II., and when, of course, taxation was much lighter, and the rate of profits much higher than at any subsequent period.*

Low Profits cause the Transfer of Capital to other Countries.

High *proportional* wages and low profits, for they are inseparably connected, ought never to be made the subject of complaint, if they occur in the natural progress of society, under a parsimonious government, and a system of perfectly free intercourse with other countries. But if they are the result of heavy taxation caused by profuse expenditure, or by restrictions which prevent the importation of cheap foreign corn, and which, therefore, force the cultivation of inferior soils at home, they cannot be too strongly condemned. A nation placed in such circumstances must not only advance slowly, when compared with other nations which are enabled to raise their supplies of raw produce from superior soils —the power to accumulate capital must not only be diminished, but a strong temptation must be held out to transfer it to other countries. The love of country—the thousand ties of society and friendship —the ignorance of foreign languages, and the desire to have one's stock employed under their own inspection, will, no doubt, in very many instances, induce capitalists to rest contented with a *less* rate of profit in their own, than they might realise by investing their funds in other countries. But this love of

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* For an account of the effect of heavy taxes on the industry of Holland, see the second volume of the *Traité de la Richesse de la Hollande*, pp. 39 and 179; and a memoir *On the Means of Redressing and Amending the Trade of the Republic*, drawn up from information communicated by the best informed merchants, and published by order of the Stadtholder, William IV. Prince of Orange, in 1751. This memoir was translated into English, and published in London in the same year.

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country has its limits. The *love of gain*—the *auri sacra fames*—is a no less powerful and constantly operating principle; and if capitalists are once assured that their stock can be laid out with equal security, and with considerably greater advantage, in foreign states, an efflux of capital to a greater or less extent will unquestionably take place.

A manufacturing and commercial country, which has wisely adopted a liberal commercial system, has no reason to be alarmed at the effects of competition in any department of industry. The production of one commodity opens a market for the exchange, that is, for the *sale* of some other commodity. What a manufacturing and commercial nation has really to fear is, that its *average rate of profit* should fall lower than the average rate of profit in the neighbouring countries. If this should be the case, its progress will, in consequence, be retarded; and it will ultimately languish and decline. Neither the skill, industry, and perseverance of artizans, nor the most improved and powerful machinery, can permanently withstand the paralyzing and deadening influence of a comparatively low rate of profit. And such a comparative reduction, it must never be forgotten, will be constantly produced by a *comparatively heavy taxation*, and by acting on *a factitious and exclusive commercial system*; for, by preventing the importation of cheap foreign corn, we necessarily *force the cultivation of poor soils, and thus by raising proportional wages, sink profits.*

Part IV.—Consumption of Wealth.

Having in the previous sections endeavoured to explain the means by which labour is facilitated, and wealth produced, and to investigate the laws regulating its distribution among the various classes of the society, we come now to the *third* and last division of the science of Political Economy, or to that which treats of the Consumption of Wealth.

Definition of Consumption—Consumption the end of Production—Test of Advantageous and Disadvantageous Consumption—Error of Dr Smith's Opinions with respect to Unproductive Consumption—Error of those who contend, that to facilitate Production it is necessary to encourage Consumption—Cause of Gluts—Consumption of Government—Conclusion.

Definition of Consumption.

We formerly showed, that, by the production of a commodity was not meant the production of matter, for that is exclusively the prerogative of Omnipotence, but the giving to matter already in existence such a shape as might fit it for ministering to our wants and enjoyments. In like manner, by consumption is not meant the consumption, or annihilation of matter, for that is equally impossible as its creation, but merely *the consumption or annihilation of those qualities which render commodities useful and desirable.* To consume the products of art or industry is, therefore, really to deprive the matter of which they consist of the utility, and consequently of the exchangeable value communicated to it by labour. And hence we are not to measure consumption by the magnitude, the weight, or the number of the products consumed, but exclusively *by their value.* Large consumption is the destruction of large value, however small the bulk in which that value may happen to be compressed.

Consumption the end of Production.

Consumption, in the sense in which the word is used by Political Economists, is synonymous with *use.* We produce commodities only that we may be able to use or consume them. Consumption is the great end and object of all human industry. Production is merely a means to attain an end. No one would produce were it not that he might afterwards consume. All the products of art and industry are destined to be consumed, or made use of; and when a commodity is brought into a state fit to be used, if its consumption be deferred, a loss is incurred. All products are intended either to satisfy the immediate wants, or to add to the enjoyments of their producers; or they are intended to be employed as capital, and made to reproduce a greater value than themselves. In the *first* case, by delaying to use them, it is plain we either refuse to satisfy a want, or deny ourselves a gratification it is in our power to obtain;—and in the *second*, by delaying to use them, it is equally plain we allow the instruments of production to lie idle, and lose the profit that might be derived from their employment.

Test of advantageous Consumption.

But, although all commodities are produced only to be consumed, we must not fall into the error of supposing, that all consumption is equally advantageous to the individual, or the society. If an individual employs a set of labourers to build him a house the one summer, and to pull it down the next, their labour, or rather the capital he gave them in exchange for their labour, and which they have consumed during the time they were engaged in this futile employment, is evidently destroyed for ever, and absolutely lost both to himself and the public; whereas, had he employed them in the raising of corn, or in the production of any species of valuable produce, he would have obtained commodities of equal, or more than equal, value to the capital he gave them. *The value of the return*, or *the advantage obtained from the consumption*, is, therefore, the true and only test of advantageous and disadvantageous, or, as it is more commonly termed, of productive and unproductive consumption. Commodities are consumed *productively* when the advantage or benefit accruing in consequence to their possessors, or when the value of the products obtained in their stead *exceeds* their value; and they are consumed *unproductively* when the value of the advantage or benefit, or the value of the new commodities, is *less* than their value. It is on this balance of consumption and reproduction, and not, as was so long supposed, on the balance of trade, that the prosperity or decay of every nation depends. If, in given periods, the commodities produced in a country exceed those consumed in it, the means of increasing its capital will be provided, and its population will either increase, or the actual numbers will be better accommodated, or both. If the consumption in such periods fully equals the reproduction, no means will be afforded of increasing the stock or capital of the nation, and society will be at a stand. And if the consumption exceeds the reproduction, every succeeding period will see the society worse supplied; its prosperity and population will evident-

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ly decline, and pauperism will gradually and progressively spread itself over the whole country.

It is impossible, however, to fix on any standard by a comparison with which we may be able to obtain even a tolerable approximation to the comparative value or advantage of different kinds of consumption. This is a point on which the sentiments of no two individuals can ever exactly coincide. The opinions of each will always depend more or less on the situation in which he is placed. The rich man will naturally be inclined to give a greater extension to the limits of advantageous consumption than the man of middling fortune; and the latter than the man who is poor. And it is undoubtedly true that a man's expences ought always to bear some proportion to the magnitude of his fortune, and his condition in society; and that what might be proper and advantageous expenditure in one case, might be exceedingly improper and disadvantageous in another. It is, therefore, quite impossible to frame any system of rules on the subject of expenditure, which shall be applicable to the case of every individual; and even if it were practicable, there is no ground to think that the formation of such rules would be of the smallest utility. The state has no right whatever to control individual expenditure; nor, even if it had such a right, could it exercise it without occasioning serious injury. The public interest requires that the national capital should, if possible, be constantly kept on the increase; or, which is the same thing, that the consumption of any given period should be made the means of reproducing a greater value. But we have sufficiently proved that this cannot, in any case, or under any circumstances, be the result of a system of *surveillance* and restriction. Industry and frugality never have been, and never can be, promoted by such means. To render a man industrious, secure him the peaceable enjoyment of the fruits of his industry;—to wean him from extravagance, and to render him frugal and parsimonious, allow him to reap all the disadvantage of the one line of conduct, and all the advantage of the other. The poverty and loss of station which is the necessary and inevitable result of improvident and prodigal consumption, is a sufficient security against its ever becoming injuriously prevalent; and wherever the public burdens are moderate, property protected, and the perfect and uncontrolled freedom of industry secured, the constant efforts of the great body of the people to rise in the world and improve their condition, will ensure the continued increase of national wealth. It is idle to expect that all unproductive and unprofitable expenditure can ever be avoided; but the experience of all tolerably well governed states proves, that the amount of the produce of industry productively expended, is always infinitely greater than that which is expended unproductively.

Luxury not disadvantageous.

It was long a prevalent opinion among moralists, that the labour bestowed on the production of luxuries, and consequently their consumption, was unproductive. But this opinion is now almost universally abandoned. Unless, indeed, all comforts and enjoyments are to be proscribed, it is impossible to say where necessaries end, and luxuries begin. But if we are to understand by necessaries such products only as are absolutely required for the support of human life, every thing but wild fruits, roots, and water, must be deemed superfluous; and in this view of the matter, the peasantry of Ireland, who live only on potatoes and butter-milk, must be considered as contributing much more to the national wealth than the peasantry of Britain! The mere statement of such a doctrine is sufficient for its refutation. Every thing that stimulates exertion is advantageous. The mere necessaries of life may be obtained with comparatively little labour; and those savage and uncivilized hordes, who have no desire to possess its comforts, are proverbially and notoriously indolent and dissipated. To make men industrious—to make them shake off that lethargy which is natural to them, they must be inspired with a taste for the luxuries and enjoyments of civilized life. When this is done, their artificial wants will become equally clamorous with those that are strictly necessary, and they will increase exactly as the means of gratifying them increase. Wherever a taste for comforts and conveniencies has been generally diffused, the wants and desires of man become altogether unlimited. The gratification of one leads directly to the formation of another. In highly civilized societies, new products and new modes of enjoyment are constantly presenting themselves as motives to exertion, and as means of rewarding it. Perseverance is, in consequence, given to all the operations of industry; and idleness, and its attendant train of evils, almost entirely disappear. "What," asks Dr Paley, "can be less necessary, or less connected with the sustentation of human life, than the whole produce of the silk, lace, and plate manufactory? Yet what multitudes labour in the different branches of these arts! What can be imagined more capricious than the fondness for tobacco and snuff? Yet how many various occupations, and how many thousands in each, are set at work in administering to this frivolous gratification!" It is the *stimulus* which the desire to possess these articles of luxury gives to industry that renders their introduction advantageous. The earth is capable of furnishing food adequate for the support of a much greater portion of human beings than can be employed in its cultivation. But those who are in possession of the soil will not part with their produce for nothing; or rather, they will not raise at all what they can neither use themselves nor exchange for what they want. As soon, however, as a taste for conveniencies and luxuries has been introduced, the occupiers of the ground raise from it the utmost that it can be made to produce, and exchange the surplus for such conveniencies and gratifications as they are desirous of obtaining; and, in consequence, the producers of these articles, though they have neither property in the soil, nor any concern in its cultivation, are regularly and liberally supplied with its produce. In this way, the quantity of *necessaries*, as well as of useful and agreeable products, is vastly increased by the introduction of a taste for luxuries; and the population are, in consequence, not only better provided for, but their numbers are proportionably and greatly augmented.

It is plain, therefore, that the consumption of lux-

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uries cannot, provided it be confined within proper limits, be justly considered as either disadvantageous or unproductive. If, indeed, a man were to consume more luxuries than his labour or his fortune enabled him to command, his consumption would be disadvantageous. But it is plain, the same thing would equally have happened had he consumed a greater quantity of *necessaries* than he could afford. The mischief does not consist in the *species* of articles consumed, but in the *excess of their value* over the means of purchasing them possessed by the consumers. This, however, is a fault which ought always to be left to be corrected by the *self-interest* of those concerned. The poverty and degradation caused by indulging in unproductive consumption is a natural and sufficient guarantee against its ever being carried to an injurious extent. To attempt to lessen unproductive consumption by proscribing luxury, is really the same thing as to attempt to enrich a country by taking away some of the most powerful motives to production.

Dr Smith's Criterion of Productive and Unproductive Consumption.

Dr Smith has given another criterion of productive and unproductive consumption; but his opinions on this subject, though exceedingly ingenious, and supported with his usual ability, appear to rest on no solid foundation. He divides society into two great classes. The *first* consists of those who fix, or, as he terms it, "realize their labour in some particular subject, or vendible commodity, which lasts for some time at least after that labour is past;" the *second*, of those whose labour leaves nothing in existence after the moment of exertion, but perishes in the act of performance. The former are said by Dr Smith to be *productive*, the latter *unproductive*, labourers. Not that, in making this distinction, Dr Smith means to undervalue the services performed by the unproductive class, or to deny that they are often of the highest utility; for he admits that such is frequently the case: but he contends, that these services, however useful, do not augment the *wealth* of the country; and, consequently, that the commodities consumed by this class are unproductively consumed, and have a tendency to impoverish, not to enrich, the society. But to avoid the chance of misrepresentation, we shall give Dr Smith's opinions in his own words.

"There is one sort of labour," says he, "which adds to the value of the subject upon which it is bestowed; there is another which has no such effect. The former, as it produces a value, may be called productive; the latter unproductive labour. Thus the labour of a manufacturer adds, generally, to the value of the materials which he works upon, that of his own maintenance, and of his master's profit. The labour of a menial servant, on the contrary, adds to the value of nothing. Though the manufacturer has his wages advanced to him by his master, he, in reality, costs him no expence, the value of those wages being generally restored, together with a profit, in the improved value of the subject upon which his labour is bestowed. But the maintenance of a menial servant never is restored. A man grows rich by employing a multitude of manufacturers; he grows poor by maintaining a multitude of menial servants. The labour of the latter, however, has its value and deserves its reward as well as that of the former. But the labour of the manufacturers fixes and realizes itself in some particular subject, or vendible commodity, which lasts for some time at least after that labour is past. It is, as it were, a certain quantity of labour stocked and stored up to be employed, if necessary, upon some other occasion. That subject, or, what is the same thing, the price of that subject, can afterwards, if necessary, put into motion a quantity of labour equal to that which had originally produced it. The labour of the menial servant, on the contrary, does not fix or realize itself in any particular subject or vendible commodity. His services generally perish in the very instant of their performance, and seldom leave any trace or value behind them for which an equal quantity of service could afterwards be procured.

"The labour of some of the most respectable orders in the society is like that of menial servants, *unproductive of any value*, and does not fix or realize itself in any permanent subject or vendible commodity, which endures after that labour is past, and for which an equal quantity of labour could afterwards be procured. The sovereign, for example, with all the officers both of justice and war who serve under him, the whole army and navy, are unproductive labourers. They are the servants of the public, and are maintained by a part of the annual produce of the industry of other people. Their service, how honourable, how necessary, or how useful soever, produces nothing for which an equal quantity of service can afterwards be procured. The protection, security, and defence of the commonwealth, the effect of their labour this year, will not purchase its protection, security, and defence for the year to come. In the same class must be ranked some both of the greatest and most important, and some of the most frivolous professions: churchmen, lawyers, physicians, men of letters of all kinds; players, buffoons, musicians, opera-singers, opera-dancers, &c. The labour of the meanest of these has a certain value, regulated by the very same principles which regulate that of every other sort of labour; and that of the noblest and most useful produces nothing which could afterwards purchase or procure an equal quantity of labour. Like the declamation of the actor, the harangue of the orator, or the tune of the musician, the work of all of them perishes in the very instant of its production." (*Wealth of Nations*, II. p. 1.)

Dr Smith's Distinction between the Different Classes of Society shown to be ill-founded.

Such are the opinions of Dr Smith, and it will not, we think, be very difficult to show the fallacy of the distinction he has endeavoured to establish between the labour, and consequently also the consumption, of the different classes of society. To begin with the case of the menial servant:—Dr Smith says, that his labour is *unproductive*, because it is not realized in a vendible commodity, while the labour of the manufacturer is *productive*, because it is so realized. But of what, may we ask, is the labour of the manufacturer really productive? Does it not consist exclusively of comforts and conveniencies required for the use and accommodation of society? The manufacturer is *not* a producer of

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matter, but of *utility* only. And is it not obvious that the labour of the menial servant is also productive of utility? If, for example, the labour expended in converting the wool of the sheep into a coat be, as it unquestionably is, productive, then surely the labour expended in cleaning and brushing the coat, and rendering it fit to be worn, must be so too. It is universally allowed, that the labour of the husbandman in raising corn, beef, and other articles of provision, is productive; but if so, why is the labour of the menial servant who performs the *necessary* and *indispensable* task of preparing and dressing these articles, and fitting them to be used, to be stigmatized as unproductive? It is clear to demonstration, that there is no difference whatever between the two species of industry—that they are either both productive, or both unproductive. To produce a fire, is it not just as necessary that coals should be carried from the cellar to the grate, as that they should be carried from the bottom of the mine to the surface of the earth? And if it is said, that the miner is a productive labourer, must we not also say the same of the servant, who is employed to make and mend the fire? The whole of Dr Smith's reasoning proceeds on a false hypothesis. He has made a distinction where there is none, and where *there can be none*. The end of all human exertion is the same—that is, to increase the sum of necessaries, comforts, and enjoyments; and it must be left to the judgment of every man to determine what proportion of these comforts he will have in the shape of menial services, and what in the shape of material products. It is an error to suppose that a man is impoverished by maintaining menial servants, any more than by indulging in any other species of expence. It is true he will be ruined if he keeps more servants than he has occasion for, or than he can afford to pay; but his ruin would be equally certain were he to purchase an excess of food or clothes, or to employ more workmen in any branch of manufacture than are required to carry it on, or than his capital could employ. To keep two ploughmen when one only might suffice, is just as improvident and wasteful expenditure as it is to keep two footmen to do the business of one. *It is in the extravagant quantity of the commodities we consume or of the labour we employ, and not in the particular species of commodities or labour, that we must seek for the causes of impoverishment.*

Case of the Physician.

The same reasoning applies to all the other cases mentioned by Dr Smith. Take, for example, the case of the physician. Dr Smith tells us that he is an unproductive labourer, because he does not directly produce something that has exchangeable value. But if he does the same thing *indirectly*, what is the difference? If the exertions of the physician are conducive to health, and if, as is undoubtedly the case, he enables others to produce more than they could do without his assistance, then it is plain he is *indirectly*, at least, if not directly, a productive labourer. Dr Smith makes no scruple about admitting the just title of the workman employed to repair a steam-engine to be enrolled in the productive class; and yet he would place a physician, who had been instrumental in saving the life of an Arkwright or a Watt, among those that are unproductive! It is impossible that these inconsistencies and contradictions could have occurred to Dr Smith; and the errors into which he has fallen in treating this important branch of the science, shows in the strongest manner the absolute necessity of advancing with extreme caution, and of subjecting every theory, how plausible and ingenious soever it may appear when first stated, to a severe and patient examination.

The amusements furnished by players, singers, and so forth, come under the description of luxuries, and have precisely the same effect on the public wealth as the introduction of a taste for tobacco, tea, or other superfluities. They create new wants, and by so doing, stimulate our industry to procure the means of gratifying them. They are really, therefore, a means of production; and while they furnish us with elegant and amusing recreation, they certainly add to the mass of useful material products.

Public Functionaries Productive Labourers.

The productiveness of the higher class of functionaries mentioned by Dr Smith is still more obvious. So far, indeed, from being unproductive, they are, when they discharge properly the duties of their high station, the most productive labourers in a state. Dr Smith says, that the results of their service, that is, to use his own words, "the protection, security, and defence of the commonwealth any one year, will not purchase its protection, security, and defence for the year to come." But this is plainly an error. We do not say that the protection and security afforded by good government is directly a cause of wealth; but it is plain that without this security and protection, the productive powers of industry could not have been called into action. Dr Smith would allow that the material products produced by the society one year, were to form the means of producing its supplies of necessaries, conveniencies, and enjoyments during the following year. But without the security and protection afforded by government, these products would either have not existed at all, or their quantity would have been very greatly diminished. How, then, is it possible to deny that those whose labour is necessary to afford this security are productively employed? Take the case of the labourers employed to construct fences; no one ever presumed to doubt that their labour is productive; and yet they do not contribute *directly* to the production of corn or of any other valuable product. The object of their industry is to give protection and security; to guard the fields that have been fertilized and planted by the husbandman from depredation; and to enable him to prosecute his employments without having his attention distracted by the care of watching. But if the security and protection afforded by the hedger and ditcher justly entitle them to be classed among those who contribute to enrich their country, on what principle can we reckon those public servants whose exertions protect property in the mass, and render every portion of it secure against hostile aggression, and the attacks of thieves and plunderers, be said to be unproductive? If the labourers who protect a single corn field from the neighbouring crows and cattle be productive, then surely the

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judges and magistrates, the soldiers and sailors, who protect every field in the empire, and to whom it is owing that every class of inhabitants feel secure in the enjoyment of their property, rights, and privileges, have a right to be classed among those whose services are supereminently productive.

That much wealth has been unproductively consumed by the servants of the public, both in this and other countries, it is impossible to doubt. But we are not to argue from the abuses extrinsic to a beneficial institution against the institution itself. If the public pay their servants excessive salaries, or employ a greater number than is required for the purposes of good government and security, it is their own fault. Their conduct is quite the same as that of a manufacturer who should pay his labourers comparatively high wages, and employ more of them than he had occasion for. But, although a state or an individual may act in this foolish and extravagant manner, it would obviously be the extreme of folly and absurdity to conclude from thence that *all* public servants and *all* manufacturing labourers are unproductive! If the establishments which provide security and protection be formed on an extravagant scale, if we have more judges or magistrates, more soldiers or sailors, than are necessary, or if we pay them larger salaries than would suffice to procure the services of others, let their numbers and their salaries be reduced. The excess, if there be any, is not a fault inherent in the nature of such establishments, but results entirely from the extravagant scale on which they have been arranged.

Consumption ought not to be encouraged for the sake of stimulating Production.

But, in showing that Dr Smith was mistaken in considering the consumption of menial servants, and of lawyers, physicians, and public functionaries unproductive, we must beware of falling into the opposite extreme, and of countenancing the erroneous and infinitely more dangerous doctrine of those who contend that consumption, even when most unproductive, ought to be encouraged as a means of stimulating production, and of increasing the demand for labour! The consumption of the classes mentioned by Dr Smith is advantageous, because they render services in return, which those who employ them, and who are the only proper judges in such a case, consider to be of greater value than the wages they pay them. But the case would be totally different, if the Government and those who employ labourers, were to do so, not in order to profit by their services, but to stimulate production by their consumption! It is a fallacy and an absurdity to suppose that production can ever be encouraged by a wasteful consumption of the products of industry. A man is stimulated to produce when he finds a ready market for the produce of his labour, that is, when he can readily exchange them for other products. *And hence the true and only encouragement of industry consists, not in the increase of wasteful and improvident consumption, but in the increase of production.* Every new product necessarily forms a new equivalent, or a new means of purchasing some other product. It must always be remembered, that the mere existence of a *demand*, how intense soever it may be, cannot of itself be a means of encouraging production. To become a real demander, a man must not only have the *will*, but he must also have the *power*, to purchase the commodity he wishes to possess; or, in other words, he must be able to offer an equivalent for it. There never has been, nor is it in the nature of things that there ever can be, any limits to our wish to possess the products of art and industry. It is the *power* to give effect to our wishes, or to furnish other products in exchange for those we are desirous of obtaining, that is the real and only desideratum. The more, therefore, that this power is increased, that is, the more industrious every individual becomes, his means of offering equivalents for the products of others will be so much the more increased, and the market will be rendered so much the more extensive.

Unproductive Consumption not necessary to prevent Gluts.

Mr Sismondi and Mr Malthus have, indeed, contended, in opposition to this doctrine, that the productiveness of industry may really be carried to excess; and that, in a country where there are great facilities of production, a large unproductive consumption is necessary to stimulate industry, and prevent the overloading of the market. But if we attend to the motives which cause men to engage in any branch of industry, we shall be satisfied that the apprehensions of these writers are unfounded, and that the utmost facility of production can never be productive of a permanent glut of the market, or require to be counteracted by means of unproductive expenditure. In exerting his productive powers, every man's object is either directly to consume the produce of his labour himself, or to exchange it for such commodities as he wishes to obtain from others: If he does the first—if he directly consumes the produce of his industry, there is an end of the matter, and it is evident that the multiplication of such produce to infinity could never occasion a glut: If he does the second—if he brings the produce of his industry to market, and offers it in exchange for other commodities, then, and then only, there may be glut; but why? Not certainly because there has been any excess of production, but because the producers have not properly adapted their means to their ends. They wanted, for example, to obtain silks, and they offered cottons in exchange for them; the proprietors of the silks were, however, already sufficiently supplied with cottons, and they wanted broad cloths. The cause of the glut is, therefore, obvious. It consists not in over-production, but in the production of cottons, which were not wanted, instead of broad cloths, which were wanted. Let this error be rectified, and the glut will disappear. Even supposing the proprietors of silks to be not only supplied with cottons, but with cloth and every other commodity that the demanders can produce, it would not invalidate the principle for which we are contending. If those who want silks cannot obtain them from those who have them, by means of an exchange, they have an obvious resource at hand—let them cease to produce the commodities which they do not want, and *directly produce the silks which they do want, or substitutes for them.* It is plain, therefore, that the utmost facility of production can never be a means of overloading the market. Too much of one commodity may occa-

Consumption of Wealth.

sionally be produced; but it is quite impossible that there can be too great a supply of every species of commodities. For every excess there must be a corresponding deficiency. The fault is not in producing too much, but in producing commodities which do not suit the tastes of those with whom we wish to exchange them, or which we cannot ourselves consume. If we attend to these two grand requisites, we may increase the power of production a thousand or a million of times, and we shall be as free of all excess as if we diminished it in the same proportion. Unproductive consumption is not, therefore, necessary to prevent the overloading of the market; and to maintain that it contributes to increase national wealth in any other way, is really just the same thing as to maintain that wealth would be increased by throwing a portion of it into the sea or the fire. *

Error of Montesquieu.

Montesquieu has said, and the same sentiment has been expressed in a thousand different shapes, "*Si les riches ne depensent pas beaucoup les pauvres mourront de faim.*" (Liv. VII. chap. 4.) Montesquieu was betrayed into this error, from his being unacquainted with the nature and functions of capital. The profusion of the rich, far from being of any advantage to the poor, is really one of the greatest calamities that can befall them. It is impossible that the demand for labour can be increased without an increase of capital. When the parsimonious principle predominates, capital increases, and as capital increases, the demand for labour is increased, the existing inhabitants are better provided for, and their numbers are increased; on the contrary, wherever profusion and wasteful expenditure predominates, capital is diminished, the inhabitants are daily worse and worse provided for, and idleness, pauperism, and disease prevail. Besides, it must be remembered, that what is annually saved, is as regularly consumed as what is annually spent. The only difference is, that it is consumed in a *different* manner—consumed by those who render a greater value in return, instead of being consumed by such as render no real value whatever. †

"By what a frugal man annually saves," says Dr Smith, "he not only affords maintenance to an additional number of labourers for that or the ensuing year, but, like the founder of a public workhouse, he establishes, as it were, a perpetual fund for the maintenance of an equal number in all time to come. The perpetual allotment and destination of this fund, indeed, is not always guarded by any positive law, by any trust-right, or deed of mortmain. It is always guarded, however, by a very powerful principle, the plain and evident interest of every individual to whom any share of it shall ever belong. No part of it can afterwards be employed to maintain any but productive hands, without an evident loss to the person who thus perverts it from its proper destination." (*Wealth of Nations*, II. p. 14.)

We have already stated the impossibility of laying down any general rules on the subject of individual consumption. What the public is really interested in is, that it should never be carried on for the absurd purpose of occasioning a demand for the products of industry, and that it should be *less* than the reproduction; or, in other words, that the capital of the country should be kept constantly on the increase. But there is no instance of any people having ever missed an opportunity to save and accumulate. And in all tolerably well governed countries the principle of accumulation in individuals has always had a marked ascendancy over the principle of expence, and the national capital, and, consequently, the riches of the country, have been constantly augmented.

Consumption of Government.

But this is seldom the case with the consumption carried on by governments and their servants. Individuals are fully sensible of the value of the articles they expend. In the vast majority of instances, they are the direct result of their industry, perseverance, and economy; and they will not consume them, unless to obtain an equivalent advantage. But such is not the situation of governments. They con-

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* M. Say was the first who showed, in a satisfactory manner, that effective demand depends upon production. (See his chapter *De Debouchés.*) But the principles from which his conclusions are drawn had been stated so early as 1752, in a tract of Dean Tucker's, entitled *Queries on the late Naturalization Bill.* As this tract is now become of rare occurrence, we shall subjoin the queries referred to.

"Whether it is possible, in the nature of things, for ALL trades and professions to be *overstocked?* And whether, if you were to remove any proportional number from each calling, the remainder would not have the same grounds of complaint they had before?

"Whether, in fact, any tradesman thinks there are too many of *other occupations* to become his customers; though narrow selfish views lead him to wish there were fewer of his own trade?

"If a particular trade be at any time overstocked, will not the disease cure itself? That is, will not some persons take to other trades, and fewer young people be bred up to that which is least profitable? And whether any other remedy but this is not, in fact, curing *one transient disorder by bringing on many which are dangerous, and will grow inveterate?*

"WHETHER IT IS NOT AN INFALLIBLE MAXIM, THAT ONE MAN'S LABOUR CREATES EMPLOYMENT FOR ANOTHER?" (p. 13.)

For a farther demonstration of the same principle, see Mr Mill's *Commerce Defended*, p. 80.

† For a farther and very able discussion of the opinion of Montesquieu, see the 7th chapter of the *Commentaire sur l'Esprit des Loix* of M. Destutt-Tracy, and Tom. IV. p. 383, of the *Elemens d'Ideologie* of the same author.

Consumption of Wealth.

sume the produce of the labour of *others*, not of their own; and this circumstance prevents them from being so much interested in its profitable expenditure, and so much alive to the injurious consequences of extravagant and wasteful expenditure as their subjects. But economy on the part of government, though more difficult to be obtained, is of infinitely greater importance than economy on the part of any individual. Should a private gentleman think of acting on the principle that profusion is a virtue, and that industry may be encouraged by increasing unprofitable consumption, he will most certainly be ruined; his ruin, however, will only be *directly* injurious to the individuals in his own employment, and will have but a very slight *indirect* effect on others. But similar conduct on the part of government would most probably be productive either of revolution, or of national poverty and degradation. If, then, it is most desirable that individuals should have a correct knowledge of their real interest in the consumption of commodities; how much more so must it be that government should possess that knowledge? Economy and frugality are virtues in a private station; but in a public station their influence upon national happiness is so vast, that they are not only the first of virtues, but the most pressing of duties.

Opinion of M. Say.

"Si les depenses publiques," M. Say observes, "affectent la somme des richesses précisément de la même maniere que les depenses privées, les mémes principes d'economie doivent presider aux unes et aux autres. *Il n'y a pas plus deux sortes d'economie, qu'il n'y a deux sortes de probité, deux sortes de morale.* Si un gouvernement comme un particulier font des consommations desquelles il doive resulter une production de valeur superieure a la valeur consommé, ils exercent une industrie productive; si la valeur consommé n'a laissé aucun produit, c'est une valeur perdue pour l'une comme pour l'autre, mais qui en se dissipant, a fort bien pu rendre le service qu'on en attendait. Les munitions de guerre et de bouche, le tems et les travaux de fonctionnaires civils et militaires qui ont servi a la defense de l'etat, n'existent plus, quoique ayant été parfaitement bien employés, il en est des ces choses comme de denrées et des services qu'une famille a consommés pour son usage. Cet emploi n'a presentée aucun avantage autre que la satisfaction d'un besoin; si le besoin n'existoit pas, la consommation, la depense, n'ont plus été qu'un mal sans compensation. Il en est de même des consommations de l'etat;—consommer pour consommer, depenser par systeme, réclamer une service pour l'avantage de lui accorder une salaire, anneantir une chose pour avoir occasion de la payer est une extravagance de la part d'un gouvernement comme de la part d'un particulier, dans un petit etat comme dans un grand, dans une republique comme dans un monarchie. Un gouvernement dissipateur est même bien plus coupable qu'un particulier: celui ci consome les produits qui lui appartienment, tandis qu'un gouvernement n'est pas proprietaire: il n'est qu'administrateur de la fortune publique." (Tome II. p. 268.)

Conclusion.

We have now shown how labour may be rendered most productive of wealth—how that wealth is distributed among the various classes of the society—and how it may be most advantageously consumed. We have shown the close and indissoluble connection subsisting between private and public opulence, and that whatever has any tendency to increase the former, must, to the same extent, increase the latter;—and we have shown that SECURITY OF PROPERTY, FREEDOM OF INDUSTRY, AND MODERATION IN THE PUBLIC EXPENDITURE, are the only, as they are the certain, means by which the various powers and resources of human talent and ingenuity can be called into action, and society made continually to advance in the career of wealth and civilization. Every increase of security or of freedom is a benefit, as every diminution, whether of the one or the other, is an evil. It is by the spontaneous and unconstrained efforts of individuals to improve their condition and to rise in the world, and by these efforts only, that nations become rich and powerful. The labour and the savings of individuals are at once the source and the measure of national opulence and public prosperity. They may be compared to the drops of dew which invigorate and mature all vegetable nature. None of them has singly any perceptible influence; but we owe the foliage of summer and the fruits of autumn to their combined action. (s. s.)

POLYNESIA,

Polynesia.

Characteristic Distinction.

A NAME given by several early writers on geography, but first, we believe, by De Barros, to the numerous islands scattered over the Pacific Ocean, or, as it was usually called, the Great South Sea. It is the name which is now applied by most modern geographers to the *sixth* great division of the earth's surface; a division which will probably appear, on examination, less arbitrary than some others; for whether we consider it in a political, physical, or moral point of view, the separation from America on the one hand, and from Australasia and the Asiatic Islands on the other, is marked by strong and distinct features. A considerable portion of the two last, for instance, have, ages ago, been invaded and taken possession of by foreigners, and many of them more recently been colonized by Europeans. No colonies have yet been planted in Polynesia, with the exception of that on one of the Ladrone Islands by Spain; numbers of its islands have never yet been visited; and the rest only occasionally by passing navigators, or a few of the most inviting by some missionaries, with the sole object of the conversion of the natives to Christianity. The inhabitants have no political connection with any of the other divisions of the earth, and little or none exists between any two of its groups or separate islands, each being governed by its own chiefs, and confining its friendships or hostilities to some neighbouring group or island.

Physically considered.

Physically considered, the line of separation is almost as distinct as their political seclusion. If a line be drawn in a south-easterly direction, along the eastern extremity of the Philippine Islands, Mindanao, Papua or New Guinea, New Ireland, and Solomon's Archipelago, and from thence continued southerly along the eastern shores of the New Hebrides and New Zealand, this line will mark with sufficient precision the separation of the Asiatic Islands (mostly to the northward of the equator) and Australasia (to the southward of the equator) from Polynesia. Besides, the geological structure of the islands which constitute the last mentioned divisions are, generally speaking, essentially different; consisting chiefly of lofty mountains, of primary or secondary formation, partaking of the same structure as those on the continent of Asia, with which some of them, indeed, may probably have once been connected, their rugged sides presenting, as it were, a broken barrier to the Great Pacific; whereas Polynesia exhibits a series of low, flat islands, scarcely rising above the level of the sea, which, with the exception of a few of the larger groups of volcanic formation, are the labours of minute sea-animals, and are usually distinguished by the name of Coral Islands or Reefs.

Morally considered.

In a moral point of view, the distinctive character of the Polynesians is as strongly marked as the physical structure of the islands which they inhabit. In the Eastern Archipelago, or the Asiatic Islands, and in Australasia, two distinct races of men have been traced, the *black* and the *brown*. In the Archipelago, and more particularly in the Philippine Islands, a few individual families of the Negro race were discovered by the early European visitors; in New Guinea and the Papuan Islands, the whole population appears to consist of this race. They differ in some respects from the negroes of the western coast of Africa; resembling rather those which are found on the eastern coast, particularly in the hair, which is strongly twisted into small tufts, and very different from that of the negro of Guinea.

Natives of Polynesia.

None of these negroes have been discovered on any of the islands of Polynesia, all the inhabitants being of the *brown* race, and evidently derived from the same common stock to which the Tartars, the Chinese, the Japanese, and the Malays, owe their origin. In this opinion Sir William Jones, Dr Buchanan, Dr Hunter, Mr Marsden, and Sir Stamford Raffles, unanimously concur. This race, modified, of course, by the circumstances of climate, occupations, and habits, may thus be described: Their persons short, squat, and robust; their lower limbs large and heavy; their arms fleshy; hands and feet small; face somewhat of a lozenge shape, the forehead and chin rather sharpened, but broad across the cheekbones, which are high, and the cheeks hollow; the eyes black, small, narrow, and placed obliquely in the head, the external angle being the highest; nose broad, but not flat, and nostrils open and circular; mouth rather wide; hair harsh, lank, and quite black.

Language.

Dispersed as the Polynesians are, and rarely and purely accidental as any communication between distant islands must be, it is perfectly certain that the different dialects spoken, from the shores of India and Africa to those of America, are the derivatives of one common language, which, according to Marsden, still forms the primitive portion of the Malay language, mixed, as it now is, with Sanscrit and Arabic. "The Malayan," says this learned and accurate writer, "is a branch or dialect of the widely extended language prevailing throughout the islands of the archipelago to which it gives name, and those of the South Sea, comprehending between Madagascar on the one side, and Easter Island on the other, both inclusive, the space of full two hundred degrees of longitude. This consideration alone is sufficient to give it claim to the highest degree of antiquity, and to originality, as far as that term can be applied."

Religion.

Not less remarkable is the general accordance of the Polynesians in manners, superstitions, and religious observances. The conversion of the Malays of the archipelago to Mahometanism has obliterated nearly their ancient faith, but enough still remains on some of the Asiatic Islands, and still more on the Asiatic Continent, to trace the source from whence the Polynesians have derived their notions and practices on matters of this kind.

Polynesia.

General View of the Islands.

These preliminary observations on the physical form, features, language, and religion of the Polynesians, are made with a view to assert their common origin, and may be taken as a general description of the natives of the various groups of islands which are scattered over the surface of the vast Pacific Ocean. These groups are exceedingly different in their extent, both as to number and size as well as in their composition. Sometimes single islands are met with, surrounded by rocky reefs. These islands and reefs are dispersed, as already observed, over the whole of the Pacific Ocean, but chiefly between the thirtieth degree of northern and the thirtieth degree of southern latitude. The following classification will probably be found to embrace the greater part of those islands which are comprehended under the geographical division, Polynesia:

In the Northern Hemisphere.

Classification of the Islands.

1. The Marian or Ladrone Islands.
2. The Carolinas, including the Pellew Islands.
3. The Sandwich Islands.
4. The numerous reefs and coral islands scattered over the Pacific in both hemispheres.

In the Southern Hemisphere.

1. The Friendly Islands, including the group of the Tonga Islands.
2. The Navigators' Islands.
3. The Society Islands.
4. The Georgian Islands, including Otaheite, and the great range extending as far as Pitcairn's Island.
5. The Marquesas.
6. Easter Island.

In the Northern Hemisphere.

The Ladrones.

1. The Ladrone Islands were first discovered by Magelhaens on the 6th March 1521. This name, by which they are generally known, was given to them by the Spaniards on account of the thievish disposition of the natives. They also called them Islas de los Velos Latinas, in reference to the sails of their canoes. By some they were called los Jardinas (the Gardens), and by others Dosprazeres (the Delightful Islands); and, when missionaries were first sent thither in 1668, under the patronage of Mary-Anne of Austria, queen of Philip, they took the name of las Marianes, in honour of that lady. They consist of four larger and several smaller islands. The former are called Saypan, Tinian, Zarpan or Rosa, and Aguigan, or rather Guahan. Saypan has a lofty peak, evidently volcanic, but the rest are of moderate height, and are surrounded by rocks of coral formation. They lie between latitude 13° and 15½° N.; longitude about 144° E. On approaching these islands, Magelhaens perceived that they were inhabited, and the natives presently came off to the ships with cocoa-nuts, yams, and rice. They were stout well-made people, of a pale yellow complexion, long black hair, and their teeth dyed red or black; an apron of the bark of a tree was their only covering; a lance pointed with a fish bone their only weapon. Their boats had latteen (shoulder of mutton) sails, with outriggers to prevent their oversetting, and they sailed with great swiftness. The captain-general was so delighted with the appearance of the country, that he intended to refresh his crew among them; but such numbers of the inhabitants flocked on board his ships, and were so addicted to thieving, that, being under the necessity of driving them away by force, hostilities ensued, and several of the natives were killed. Magelhaens had one of his boats stolen, which so exasperated him, that he landed with ninety of his people, set fire to their houses, which were of wood, and carried off all the provisions he could find.

Visited by Magelhaens.

By Loyosa.

The expedition of Loyosa, commanded, after his death, by Sebastian del Cano, and at his decease by Alonzo de Salazar, touched at the Ladrone Islands in 1526, and being received in the most friendly manner, procured water and provisions in plenty for the sickly squadron. To the great surprise of the Spaniards, a countryman of theirs, named Gonzalo de Vigo, came to them from one of the islands, having deserted from one of the ships of Magelhaens; two others, he said, had deserted at the same time, but were put to death by the natives. They found no quadrupeds on the island, but plenty of excellent fruits, fish, and rice. The only birds were turtle-doves, of which the islanders appeared to be so fond, that they kept them in cages, and taught them to speak.

By Lopez de Legaspe.

In 1565, the Ladrone Islands were again visited by Lopez de Legaspe. While the ships were yet two leagues from the shore, the natives came off in their canoes, but kept at a distance from the ships. The general put knives and other articles on a plank, and floated it off, and the natives showed fruits, patting their bellies, and pointing to the shore, to induce the Spaniards to land. This they did the following day on the island of Guahan, and exchanged bits of iron for provisions; but notwithstanding the regulations made by Legaspe in order to prevent quarrels, skirmishes took place, and one of the seamen, who had strolled into the woods, being found murdered, the Spaniards landed in force, set fire to their houses and canoes, wounded several of the natives, and hung up on the spot three wounded prisoners.

No kind of animal was found on the island, nor would the natives taste any other animal food except fish. "But that which caused most admiration," says Friar Gaspar, "was, that they would drink salt water, and were such expert swimmers, and passed so much of their time in the water, that, as among other animals, some are amphibious, in like manner it seemed as if these people were in their nature amphibious."

Visited by Cavendish.

In 1588, our countryman Candish or Cavendish came in sight of the Ladrones, and sailed along the coast of Guahan, from which a number of canoes came off with fruits and vegetables, which were exchanged for pieces of iron; but the natives became so troublesome, that, in order to get rid of them, Cavendish ordered muskets to be fired at them.

By Olivier Van Noort.

In 1600, Olivier Van Noort made the Ladrone Islands, and stopped near Guahan for two days, from which island above 200 canoes came off to the ships with fish, fruits, and rice, to exchange for iron; and fowls are also mentioned, for the first time, in this voyage. In the same year, the Santa Margarita, a

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Spanish ship, having lost her captain and many of her crew by sickness, anchored off Saypan, and was taken possession of by the natives, who killed some of the crew, and took others of them on shore, where they were kindly treated, and such as survived were afterwards taken off by a Spanish ship which had been sent for the purpose.

By Spilbergen and the Nassau Fleet.

In 1616, Spilbergen made the Ladrone Islands, and stopped two days to traffic with the natives for provisions of fruit, fowls, and fish, in exchange for bits of iron. In 1625, the fleet under Prince Maurice of Nassau refreshed at Guahan, and were supplied by 150 canoes, with immense quantities of cocoa-nuts, yams, bananas, rice, and fowls, which were of infinite service, as the scurvy had made such havock among the crews, that in some of the ships they had scarcely strength enough to manage the sails.

Of the Spanish Jesuits.

In 1668, the Spaniards established a mission on the island Guahan, consisting of P. Servitores and five other fathers, and several lay-assistants, most of them natives of the Philippine Islands, and well acquainted with the Tagul language, the same as that spoken by the natives of the Ladrone Islands. For some time the chiefs of the islands behaved with great kindness to the Jesuits, and gave them ground for building a church. From this seat of the mission the fathers spread themselves among the other islands, where they were received with equal kindness. In short, P. Servitores says, that in the first year they had baptized more than 13,000 islanders, and instructed 20,000 in the eleven islands which they had visited. As usual, however, the imprudent zeal of the missionaries ruined their cause, by shocking the prejudices of the natives. These simple people took it into their heads that, as an infant had died shortly after being baptized, its death had been occasioned in consequence of that ceremony; and such was the terror of mothers on seeing a missionary approach, that they seized their children and ran off with them into the woods. This opinion gathered ground from the eagerness of the Jesuits to get hold of infants for the purpose of baptizing them, and more than one of these holy fathers fell martyrs to their imprudent zeal. Several murders ensued; and, as the Spaniards had taken care to strengthen the mission with a body of troops well armed, with the obvious intention of taking possession of the Ladrones as an important outpost to the Philippine Islands, after a great number of the natives had been put to death, the rest submitted to the yoke of the Spaniards; though most of the missionaries suffered in the contest, and last of all Servitores, who was killed by the man to whom he had been the greatest benefactor, because the missionary insisted on baptizing his child. Thus, at the age of forty-five, this pious and good man (for such he certainly was) fell by the hand of an assassin, after having, as we are told, "established the faith in thirteen islands, founded eight churches, established three seminaries for the instruction of youth, and baptized nearly 50,000 of the islanders." From this time constant revolts and massacres, and the most inhuman cruelties, were inflicted on the unhappy islanders; so that, in 1681, the island of Guahan, which, on the first coming of the Spaniards, counted 40,000 inhabitants (some accounts make them more), was so completely depopulated, that it was found necessary to bring inhabitants from the northern islands to cultivate the soil.

Visited by the Buccaneers.

In the year 1685, the ship of John Eaton, the Buccaneer, touched at Guahan, the crew of which quarrelled with the natives, and killed some of them. Having satisfied the Spanish governor that it was done in their own defence, "he gave us toleration," says Cowley in his narrative, "to kill them all, if we could."—"We took four of these infidels prisoners," continues the narrator, "and brought them on board, binding their hands behind them; but they had not been long there, when three of them leaped overboard into the sea, swimming away from the ship, with their hands tied behind them. However, we sent the boat after them, and found a strong man, at the first blow, could not penetrate their skins with a cutlass; one of them had received, in my judgment, forty shots in his body before he died; and the last of the three that was killed had swam a good English mile first, not only with his hands behind him, as before, but also with his arms pinioned." We are told by the late Captain Burney, that it is stated in Cowley's MS. in the British Museum, that "the boat coming up with them, our carpenter, being a strong man, thought, with his sword, to cut off the head of one of them, but he struck two blows before he could fetch blood."

By Dampier.

In 1686, Dampier touched at Guahan, and states the number of natives not to exceed 100. He gives a particular description of their "flying proas," with their outriggers, which, he says, "sail the best of any boats in the world;" that he tried the swiftness of one by his log, and that she ran twelve knots out before the half-minute glass was half out."—"I believe," says Dampier, "she would run twenty-four miles in an hour." Woodes Rogers, who visited the Ladrones in 1710, states his opinion that one of these proas would sail at the rate of twenty miles an hour.

By Anson.

In the month of August 1742, Commodore Anson anchored before the island of Tinian. It was deserted, but cattle to the number of at least 10,000, hogs, and fowls, were running about wild. Cocoa-nuts in innumerable quantities, bread-fruit, oranges, limes, water-melons, and other tropical fruits, were in the greatest abundance. The island swarmed with rats, and the flies, mosquitoes, and ticks or bugs, were very troublesome; but it was a paradise to the crew of the Centurion, in the horrible state of scurvy in which they arrived. Though now deserted, Tinian, on the arrival of the Spaniards, is said to have contained 30,000 inhabitants. Ruins of buildings, consisting of pyramidal pillars of considerable dimensions, were met with in all parts of the island.

By Byron.

Commodore Byron anchored in the year 1765 before Tinian, and found the island overgrown with large trees and underwood, among which were most of the tropical fruits. He complains bitterly of the bad anchorage, break water, venomous insects, from which they suffered so severely, that "we were afraid," he says, "to lie down in our beds;" and though his crew recovered fast from the scurvy, he lost two by fevers, being the first deaths in his ship

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since leaving England. "I am, indeed, of opinion," says the Commodore, "that this is one of the most unhealthy spots in the world, at least during the season in which we were here;" yet it was in the same month when visited by the Centurion.

By Kotzebue.

The latest account of these islands is that of Lieutenant Kotzebue, who visited Guahan in 1817. No canoes nor proas, nor happy islanders, greeted his approach; the whole race of natives had long been extirpated. "We looked," he says, "in vain for a canoe or a man on the shore; and it almost seemed as if we were off an uninhabited island. The sight of this lovely country deeply affected me. Formerly these fertile valleys were the abode of a nation, who passed their days in tranquil happiness; now only the beautiful palm groves remained to overshadow their graves; a death-like silence everywhere prevailed." Soon, however, a person appeared from the Spanish governor, and piloted the ship into the harbour; and after this, Kotzebue proceeded to the town of Agana, situated on a beautiful plain, some hundred paces from the shore, in the midst of fine palm groves; some of the houses are built of coral rock, others of bamboo. It has a church and a convent, and two fortresses, one to protect the town from the seawards, the other to keep the Indians in awe. The town contains about 200 houses, and 1500 inhabitants, who derive their origin from Mexico and the Philippines. The population of the island is about 5000 souls. "There is but one man and his wife," says Kotzebue, "on the whole island of the original stock; with the death of these two people, the race of the old Ladrones will be totally extinguished."—"The present race," says Chamisso, "no longer know the sea; are no mariners, no swimmers; they have ceased to build boats. They now scarcely hollow out, without skill, the trunks of trees to fish within the breakers." All the other islands to the north of Guahan are entirely uninhabited, and overrun with wild cattle, hogs, and goats, which afford a supply to the American vessels trading to the Sandwich Islands and the north-west coast of America. Indeed, it is said that some of these people have been allowed to settle themselves in Agrigan, on condition of acknowledging their allegiance to Spain, and that they are peopling the island by kidnapping the natives of the Sandwich Islands.

The Carolinas.

2. The *Carolinas*, or Caroline Islands. In 1686, a Spanish ship, being near the meridian of the Ladrones, fell in with an island, which her Commander, Don Francisco Lazeano, named La Carolina, in honour of the King of Spain, Carlos II. This island has given the name to a very extensive chain spreading over a space of not less than six degrees of latitude, and twenty-five degrees of longitude, the western extremity being the group of the Palaos or Pellew Islands, in latitude 7° N., longitude 135° E., and the easternmost island (that of Hogolen) in latitude 9° N., longitude 155° E. The whole group, as far as is known (which, however, is very imperfectly), consists of at least 150 separate islands, and may be nearly twice as many, besides various coral reefs, with islets upon them. Yet, numerous as they are, being somewhat out of the direct and usual route of the Spaniards in their voyages from South America to the Philippines, they had the good fortune to escape any intimate connection with them—a connection which has proved equally baneful to others, whether established by the cross or the sword; by their professions of friendship or avowals of hostility. Gobien, the historian of the desolating progress of the Spaniards in the Ladrones, says, that Quiroga, the governor, made search for the island Carolina, "wishing to extend the faith to its infidel inhabitants, and, for that purpose, sent some soldiers, and with them the chanionis (or chief), Don Alonzo Soon; but, after a fruitless search, and much pains, they returned without finding the object of their research."

Some of these islands, however, and especially those towards the western extremity of the group, had been seen by various navigators long before that of Carolina was noticed and named by Lazeano. The Portuguese, Da Rocha, fell in with islands in 9° or 10° N. latitude, in 1526, which he named Sequeira, after his pilot; and, in 1628, Saavedra, a Spaniard, in his passage to the Philippines, discovered islands in latitude 11°, which he named Los Reyes. In 1579, our countryman Drake saw some islands, to which he gave the name of the Islands of Thieves, which, from his description, have been supposed to be the Pellew Islands. In 1595, one of the islands in about 6° N. was seen by Mendana; but two proas full of people, driven by the violence of the wind from a group of islands in the east, as far as Samal, roused the attention of the College of Jesuits at Manilla, who made several unsuccessful attempts to establish missions on those islands, which the wrecked natives described to consist of thirty-two in number. In 1710, the two fathers, Duberron and Cortel, embarked in the San Trinidad, with a crew of 86 men, to establish themselves on the Pellew Islands. They landed on Sonsorol, with the quarter-master and ensign of the troops, in all sixteen persons; but the ship being driven off by the current, made for another of the islands, called Panloque, at the supposed distance of fifty leagues from the Sonsorolles. On approaching the island, several boats came off, and some of the Palaos people swam from them to the ship, and coming on board, attempted to steal whatever they could lay their hands on. In consequence of this, they were ordered away; and having reached their boats, began to shoot arrows at the ship, which were answered by a discharge of musquetry. The ship now returned to the Sonsorolles, to inquire after the two missionaries and the boat; but the strong winds and currents would not suffer them to anchor, nor could they see or hear any thing of their companions, though they stood in towards the shore within cannon-shot. A storm coming on, left them no alternative but "to return to Manilla, with the sorrowful news of what had happened." What became of the missionaries was never ascertained. The following year, however, P. Serano departed from Manilla, in a ship fitted out for the purpose, in search of the two fathers and their companions; but she foundered three days after she de-

parted from Manilla, and every person on board perished, except one Spaniard and two Indians, who brought back the melancholy intelligence.

In the *Lettres Edifiantes et Curieuses* is a letter and chart from P. Juan Antonio Cantova, a missionary at Guahan, addressed to the King of Spain's confessor in 1722, in which is given a more particular account of the Carolinas than any which had before, or has since, been published. It states, that, in the preceding year, a bark, with eleven men, seven women, and six children, arrived on the east side of Guahan; and that, two days after, another canoe, with four men, one woman, and child, came to the opposite side of the island. The two parties, on being brought together, recognised each other with great joy. It appeared they had been dispersed by a gale of wind, and driven about for twenty days, without knowing where they were. Cantova thus describes them: They wore a garment open at the sides, but covering the shoulders and breast, and extending down to the knees. The women had a piece of cloth round the waist, falling, like a petticoat, to the middle of the leg. Their hair was curly, the nose large, the eyes large and penetrating, and the beards of the men moderately thick. Some had the pure colour of the Indians; others apparently of a mixed breed, between Spaniards and Indians; and others between a Negro and an Indian. Cantova succeeded in learning their language, and obtained from them the following particulars respecting their islands.

The Carolinas are divided into five provinces. Beginning at the east, the first is named Cittac; the principal island, Hogolen, much larger than Guahan; its inhabitants negroes, mulattoes, and whites. There are eighteen principal islands in this province, besides a multitude of smaller ones. The second province consists of twenty-six islands, of which Uleé and Lamurree are the principal ones. The third province consists of a group of islands, of which Feis is the principal, and is very populous and fertile; but the chief of the group resides at Mogmog, and all the proas which approach this island lower their sails in token of respect to this chief. Of the fourth province, Yap is the principal island, about 120 miles in circuit, very populous, and fruitful. The fifth province is the most westerly, and is named Panleu (the Palaos, or Pellew Islands), of which there are seven principal islands. It is remarkable that the inhabitants of these islands so far differ from the Carolinians in general, and from the account given of them in the romance of Mr Keates, drawn up by that ingenious gentleman from the documents furnished by Captain Wilson, that they are represented as a most barbarous race; both men and women going entirely naked, and feeding on human flesh. We are told by the naturalist of Kotzebue's expedition, that a Spaniard, who had lived nine months on the Pellew Islands, and whom they met with at Cavité, gave him a horrible account of the natives: that they were wholly without shame; that husbands lend their wives for a mere trifle; that the women are without modesty; and that they certainly eat human flesh; a great part of which was confirmed by a native of the Carolinas, who had been at the Pellew Islands.

Cantova farther learned from the islanders, that to the eastward were a great number of other islands, the inhabitants of which pay adoration to the shark; that most of them are negroes, and of savage dispositions. It is supposed that Cantova returned with these islanders in the year 1722, though no account of any such voyage is on record; but, in 1731, he embarked for the islands of the third province, in company with another father, of the name of Walter, from which the former never returned. The latter, however, returned to procure certain articles of which they stood in need, was driven to the Philippines, re-embarked in 1732, and was wrecked. Walter again embarked in May 1733, with forty-four persons. On the ninth day, they approached the island, and fired cannon to inform Cantova of their arrival, but no boat appeared. Standing within a musket-shot of the shore, they observed that their former habitation had disappeared, as well as the cross which had been erected near the sea shore. Four small canoes at length approached the vessel, bringing cocoa-nuts. On inquiring after Cantova and his companions, the islanders were evidently embarrassed, and said they were gone to Yap. Being fearful, by their manner, that the good father had fallen by the hands of the barbarians, and willing to be satisfied on this head, they seized one of the islanders, upon which the rest swam ashore. After the strongest assurances that no harm should be done to him, provided he would tell the truth, he confessed that shortly after the departure of Walter, the natives put the Father Cantova to death and all his companions, fourteen in number. Cantova, it seemed, from this man's account, went, with his interpreter and two soldiers, to the Island Mogmog, to baptize, while the rest remained at Falalep. He had scarcely set his foot on shore when he was surrounded and pierced through and through with lances, the natives crying out that he was come to take away the old law, and give them a new one. They gave his body a decent burial, but the bodies of his companions were put into a canoe, which was then turned adrift upon the ocean. The same people then went over to the island of Falalep, and put to death the remainder of the companions of Cantova.

Since that time, little or no information has been procured respecting the Carolinas, with the exception of that which is contained in the narrative of Mr Keates, from the materials of Captain Wilson, who, when commander of the Antelope packet, in the service of the East India Company, was wrecked on Oroolong, one of the Pellew Islands. Whatever their general character may be, the crew of the Antelope found them a friendly, hospitable, and humane people. They were stout, well-made, rather above the middle size, and their colour approaching to a deep brown; their hair long, some wearing it loose, and others turned up. The men were entirely naked; the women contented themselves with two little aprons or fringes, made of the fibres of the cocoa-nut husk, about ten inches deep and seven wide, one of which was worn before, and the other behind. Both sexes were tattoed; the men had one ear perforated, the women both, and they wore beads, tortoise-shell, or leaves, as suited their fancy; the car-

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tilage of the nose was also bored, and a little sprig or blossom of some plant was generally stuck in the hole; their teeth were dyed black by a paste prepared of certain herbs, which, it is pretended, caused severe sickness for five days, the time required to complete the operation.

Their Productions, and the Manners of the Natives.

Fish and cocoa-nuts are the chief articles of food, but the islands afford an abundant supply of yams, plantains, oranges, lemons, bread-fruit, carambola, and the areca nut; the sugar-cane grew wild. No quadruped, except rats, was found on the islands; of birds, the pigeon was the most abundant, and the domestic fowl ran wild in the woods. The natives were wholly unacquainted with the use of salt. Their usual beverage was the milk of the cocoa-nut. Their houses were of bamboo and plank, raised upon stones from the ground. The husk of the cocoa-nut supplied them with nets and cordage, and the tortoise-shell with hooks to catch fish. Their knives were made of mother-of-pearl, shells, or split bamboo; the cocoa-nut served them for cups, the plantain-leaf for plates, and the fibres of this plant for mats to sleep on. Their weapons were spears of wood, darts, and slings. Their boats were canoes, made of the trunks of large trees, and some of them sufficiently capacious to hold from twenty to thirty persons. In the day time they seemed to live as much in the water as on shore, and both sexes were admirable swimmers. The women mixed freely with the other sex, and their conduct was not strictly inquired into by their husbands. They seemed to have little sense of any religious duties, except in the ceremonies attending the burial of the dead, which takes place in spots set aside for that purpose, and with great solemnity; but they have some faint notion that the soul survives the body. Their graves very much resembled those in a country church-yard of England, some having earth heaped up in the same manner, and others covered with flat tombstones, and protected by fences of wicker work.

The larger of the Pellew Islands are of a moderate height, rising into beautiful hills, well clothed with forest trees. The natural history still remains unknown, but being about the same parallel, and of the same formation with the numerous group visited by Kotzebue, the plants and animals are in all probability much the same. The smaller islands are the productions of the coral-making animals, with which the larger are also surrounded to a great distance from their shores.

The Sandwich Islands.

3. *The Sandwich Islands.*—This fine group of islands in the Northern Pacific had the good fortune to escape the visits of the old navigators, and the discovery of them was reserved for Captain Cook, who first touched at them in the year 1778, and lost his valuable life there in 1779. M. Fleurieu, in his introduction to Marchand's *Voyage,* is disposed to dispute this claim, and to assign the first discovery of these islands to Mendana, for no other reason but that it appears he passed at no great distance from Owyhee (but without seeing it), on his return voyage in 1568; and because he finds an island named Mesa, laid down on the nineteenth parallel of latitude, on the obscure and unauthenticated chart of Galion de Manille. It is almost unnecessary to add, that the name by which they are now known was given to them by Captain Cook, in honour of the Earl of Sandwich, under whose naval administration geography was enriched with many important discoveries.

Extent and Population.

Captain King makes the group to consist of eleven islands, the principal of which are Owyhee, said to contain about 150,000 inhabitants,—its extent about 6000 square miles; Mowhee, 65,000,—extent 600 square miles; Woahoo, 60,000,—extent 1800 square miles; Atooi, 54,000,—extent 1000 square miles; and Morotoi, 36,000,—extent 300 square miles. The rest are smaller, and make up a population for the whole group of about 400,000 souls. They are situated between latitude 18° 54′ N. (the south point of Owyhee), and 22° 2′ N. (the latitude of Orehoue), and between the longitude 199° 36′ (the small island of Tahoura), and 205° 6′ (the eastern extremity of Owyhee).

The island of Owyhee is described as rising majestically in grand unbroken lines from the ocean, and forming three several mountain peaks, on two of which snow lies the greater part of the year. They are as under:

	Height.
Mouna Roa (the Great Mountain),	2482 toises.
Mouna Kuah (Little Mountain),	2180
Mouna Wororai, . .	1687

These measurements, as given by Kotzebue, agree within a few toises with those of Marchand. The whole group is of volcanic origin, and on the summit of Mouna Wororai is an immense crater. The last eruption from the side of this mountain took place in 1801. The chain of mountains runs from the N. W. point of Owyhee, over the islands Mowee, Morotoi, and Woahoo. On Mowhee is a peak as high nearly as that of Wororai, but the latter is the only volcano in a state of activity.

Description.

These islands, though volcanic, are surrounded by coral reefs, and the plains next the sea, raised only a few feet above it, were once of the same description, and covered with water. These plains are generally naked and sun-burnt, but the valleys among the mountains are beautifully picturesque and fertile, and the sides of the hills are covered with magnificent forests. The most fertile and best cultivated of the group is Woahoo, on which is the safe and capacious harbour of Hana-rura, protected by a coral reef, through a break of which the entrance to it lies. In one of the mountains a diamond mine was supposed to exist, but the products turned out to be only quartz crystals. In the Pearl River of this island oysters have been found, containing pearls, but none of much value.

Natural Productions.

Among the indigenous plants mentioned by Chamisso, the naturalist of Kotzebue's expedition, are the accacia, metrosideros, pandanus, santalum, aleurites, dracœna, amomium, curcuma, tacca. The families of rubiaceæ, contortæ, and urticæ, predominate. From the latter, as well as from the paper mulberry (*Broussonetia papyrifera*), are made their cordage and cloths. The accacia tree used for their boats and canvas grows only in the mountains, which is the case also with the sandal-wood, the principal article of export from the islands.

Cultivation.

The plants mostly in use for domestic purposes are the banana-tree, the coco-nut tree, the bread-fruit, sugar-cane, yam, batatos, and the taro-root (*Arum esculentum*), of indigenous growth; besides which have been introduced the tobacco plant, the melon, and water-melon, rice, and the vine, the last of which will unquestionably thrive well on the sides of the volcanic mountains. The cultivation of the taro-root has the greatest share of attention bestowed on it; and, in fact, it constitutes a considerable portion of the food of the people. The fields or ponds in which this root is planted are inclosed with stones in the form of regular squares, from 100 to 200 feet each side; these squares are connected by sluices to convey the water from one to the other, pretty much in the same manner that the Chinese manage their rice fields. "I have seen," says Kotzebue, "whole mountains covered with such fields, through which the water gradually flowed; each sluice formed a small cascade, which ran through avenues of sugar-cane, or banana, into the next pond, and afforded an extremely picturesque prospect."

Distillation of Spirits.

A convict from New South Wales has taught the people of these islands the art of distilling ardent spirits from sugar-cane, and a plant called the Tee-root (the *Dracœna terminalis*). And, as every chief has now his still, it is probable that the use of the pernicious *kava* will give way to that of the almost equally pernicious use of spirituous liquors. This *kava* is the liquor or juice of a root of the pepper tribe (*Piper methysticum*), chewed and spit out into a large bowl, and then diluted with water, and this exquisite beverage is prepared for the sole use of the king and the nobles, the women being prohibited from tasting it. The baneful effects of this liquor have been noticed by most voyagers; the bodies of those who swallow it are, in process of time, covered with a white scurf, their eyes become red and inflamed, their limbs emaciated, and their whole frame trembling and paralytic.

Quadrupeds.

When Captain Cook first discovered these islands, the only quadrupeds upon them were hogs, dogs, and rats. They have now horses (not many), asses, horned cattle, many of them running wild in the mountains, and goats. Hogs are exceedingly abundant. "They are so large," says Kotzebue, "that the whole crew could not eat one in two days;" and the flavour, from being fed on sugar-cane, is very superior to European pork. Fowls, ducks, and geese, are equally abundant.

Progressive Civilization.

The Sandwich Islands, though last discovered, have been more frequently visited by Europeans and Americans, and particularly by the latter, than any other group of islands in the whole range of Polynesia; and they have profited the most by such intercourse, though not by any means to that extent which might have been wished. Indeed, what little progress they have made towards civilization is mainly to be attributed to the personal character of the present chief or king, whose name is Tamaa-mah; and that which he has effected is more for his individual advantage than the good of his subjects. When Captain Vancouver visited these islands in 1792, the king being desirous of having a vessel of European construction, this able navigator laid down the keel of one, which was speedily finished. Ten or twelve years after this, when Mr Turnbull visited the islands, he had a naval force of twenty vessels or upwards, from 25 to 50 tons, which traded among the islands. He had built a house for himself, after the European manner, with windows of glass, and he imitated the English in his dress. By means of English and American seamen and artificers, some of whom deserted from ships touching there, and others obtained regular permission to remain on the islands, most of the trades exercised in Europe have partially been introduced into the Sandwich Islands.

Most of those people having taken to themselves native wives, a new race of men is springing up, which, in the course of time, may probably be the means of hastening the civilization of these islands. It is much to be regretted, however, that hitherto no steps have been taken to bring up the new generation in the principles of morality and religion, or for instructing them in the common rudiments of education. Tamaa-mah is ready enough to imitate the Europeans in his dress and dwelling, in building forts for the protection of his islands, and in training his troops in the European mode of discipline, of whom Kotzebue saw 400 drawn out, armed with musquets. In these matters, he is willing enough to be instructed by the Europeans who have settled on the islands, who, generally speaking, are of a description not likely to convince him of the utility of intellectual acquirements. In a visit to the Morai, pointing to the large wooden statues, he said to Kotzebue, "These are our gods, whom I worship. Whether I do right or wrong, I do not know, but I follow my faith, which cannot be wicked, as it commands me never to do wrong." Such sentiments do honour to the savage; and the man who entertains them is capable of being instructed in better things.

He is very tenacious in observing the customs of the country, and says, that, although those of Europeans are better, he cannot depart from his own. Thus the women continue to be degraded and despised; and, notwithstanding the frequent intercourse with strangers, and the improvements which undoubtedly have been introduced, the sex do not appear to have gained a single step in the estimation of the men, or lost any part of the grossness of behaviour since they were first visited by Captain Cook. That "offensively conspicuous wantonness," which Vancouver deplores, and to which he found no parallel in the whole of Polynesia, appears to have suffered no abatement. When Campbell, the seaman, was on the island of Woahoo, the king's brother died, on which occasion, as part of the general mourning, a public prostitution of the women took place. The captain of a ship, then in the harbour, remonstrated with the king, who coolly observed, it was their custom, and he could not prevent it. The women, too, it seems, are more addicted to drinking than the men. The governor of Woahoo invited Kotzebue and his officers to witness a dance of the natives, at which he was not present, but sent an apology to say, that his lady was so drunk that he could not leave her. The women are also great smokers of tobacco, and continue it sometimes till they fall down senseless.

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Though the women are so far degraded that they cannot eat in the same house with their lords and masters, and must not taste at all of certain articles, yet if the latter be sick, they must howl and make lamentations, tear their hair, lacerate their cheeks; and if he should die (provided he be a Jerrie, Eree, or noble), the favourite wife must die with him. The victims, both men and women, who are to be sacrificed at the death of Tamaa-mah are well known, nor is it concealed even from themselves, and they glory in the distinction. "I have myself," says Kotzebue, "seen one of the devoted victims in Woahoo, a man who was always cheerful and happy." On the death of the king, these people will be led bound into the royal Morai (temple and burning place), where, after the prescribed ceremonies, they will suffer death at the hands of the priests. Chamisso, however, says, that this inhuman practice is wearing out, and that now culprits only, whose lives have been forfeited, are sacrificed to the gods on particular occasions. But though the custom of offering up human sacrifices is still retained, there are no grounds whatever for supposing, as the surgeon of Captain Cook's ship did, that they ever taste of human flesh.

To violate the sanctity of the Morai is one of the greatest crimes of which a man can be guilty. Campbell was present at the execution of a man who had committed this offence, in getting drunk and running out of the Morai during *tabboo* time. He was taken back to the Morai, where his eyes were put out; in this state he remained two days, when he was strangled and his body exposed before the image of Etooah, or Eatooah, the principal deity, who, according to their belief, is the creator of the universe, and who afterwards destroyed it by an inundation that covered the whole earth except Mouna Roa; on the top of which one single pair had the good fortune to save themselves, from whom the present race of men, that is, the Sandwich Islanders, sprung. Each chief has his own peculiar deity and his own Morai, and dresses up his wooden god after his own fashion. The common people have also their own objects of worship in their houses—birds, beasts, fish, &c. just like the *fetishes* of the Africans on the coast of Guinea.

That singular superstition by which the king, the nobles, and the priests, under the name of *Tabboo*, have contrived to render sacred and inviolable whatever they may wish to appropriate to their own use, and which is in universal operation through the whole of Polynesia, is practised to a great extent in the Sandwich Islands. By means of it, a whole people is contented to be robbed of their property, and to suffer any privations that may be imposed on them without murmuring. When their houses are *tabbooed* they dare not enter them; when their *tarro-roots* or their hogs are tabbooed, they surrender them without a struggle; but in return, it must be owned, they are not scrupulous in appropriating to themselves whatever is not *tabbooed*.

Among the customs which they inveterately retain is that of *tattooing* the body, this operation being also universal among the islanders of the Pacific. The hands and arms of the women, in particular, are marked with peculiar elegance of figure, and many of the women have the tip of the tongue tattooed. Contrary, however, to the common practice of the islanders, they do not paint their bodies, nor wear ornaments of any kind in the ears; but the women decorate their hair, which is cut short, with wreaths of flowers, and wear necklaces, bracelets, and anklets of shells, coral, and other substances. The common dress of the men is the *maro*, a piece of cloth about a foot wide, which, passing between the legs, is tied round the waist; that of the women is a short petticoat, reaching about half-way down the thigh. The chiefs, on days of ceremony, and on particular occasions, wear cloaks made of the most beautiful feathers, with an elegant shaped helmet to correspond. They are ambitious, however, to appear in the dress of Europeans, to enable them to do which, great quantities of old laced coats are carried out to the Sandwich Islands, as articles of commerce.

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Dress and Decorations.

To whatever degree of civilization the Sandwich islanders may have attained, since the first discovery of Captain Cook, it is to be ascribed, as we said before, to the personal character of Tamaa-mah; but whether they will continue to proceed or to retrograde, on the death of this extraordinary man, is a matter of great doubt, considering the character of his son and successor. The old man, however, has caused him to be tabbooed, or made sacred, so that nobody is allowed, on pain of death, to see him by day. This being done, he receives the appellation of *Leo-leo*, "that is," says Kotzebue, "dog of all dogs; and such we really found him."—"We entered," he continues, "a neat and small house, in which Leo-leo, a tall, corpulent, and naked figure, was stretched out on his stomach, and just indolently raised his head to look at his guests; near him sat several naked soldiers armed with muskets, who guarded the monster. A handsome young native, with a tuft of red feathers, drove away the flies from him—The dog of all dogs at last rose very lazily, and gaped upon us with a stupid vacant countenance." His age is stated to be about twenty-two, but his corpulency is somewhat enormous for one so young. This description does not certainly portend much in favour of the future happiness of the Sandwich Islands, for the vacant government of which there will probably start up many competitors. An European of talent, if such there should happen to be on the spot, might probably succeed to the government and civilization of this good humoured, and by no means untractable people.

The present King and his Successor.

4. *Coral Islands and Reefs.*—The number and position of the multitude of low islands, sometimes found in groups, and sometimes solitary, are by no means yet ascertained; but from the various tracts of ships, it is known that the whole of that part of the Pacific lying between the equator and the 10° of north latitude, and from the Pellew Islands, to 180° longitude, being at least forty-five degrees of longitude, is completely studded with low coral islands and reefs in countless numbers, some of them inhabited, and others not; and in different stages, from the circular reef, with islets rising upon it like the beads of a necklace, with a lagoon in the centre, to the complete consolidation into one firm island.

Coral Islands and Reefs.

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About the tenth parallel, and proceeding easterly from the Carolinas, we have Button, Tindall, Watt's, and Gilbert's Islands; and about the longitude 175° east, a whole group, extending to the southward of the equator, named on some charts "Lord Mulgrave's Range," on others "Scarborough's Range;" some of the individual islands of which are Smith's, Allen's, Gillespie's, Toulmin's, Hopper's, Chatham's, Calvert's, Robertson's, Arrowsmith's, Daniel's, Marshall's, Pott's, near to which are Kingmill's Group and Byron's Island, all of coral formation.

Various accounts have been given by Cook, Forster, Flinders, and others, of the progressive formation of these low specks of land, with which the Pacific is studded; but the best and most satisfactory is that by Kotzebue and the naturalist Chamisso. They not only saw the "Lord Mulgrave's" chain of islands, which extend from 1° to 12° N., of which Gilbert's Islands form the northern, and Marshall's Island the southern, extremity, but they discovered and examined minutely many other groups and detached islands. Between the eighth and tenth degrees of north latitude, and between longitude 188° 48′ and 190° 46′, they fell in with no less than six distinct groups, to which they understood the natives applied the name of Radack; and they learned that to the westward were nine other groups, and three detached islands, called Ralick, besides four groups to the southward. The Radack chain is probably those which were seen by Captain Marshall in 1788, and to which he gave the name of Chatham and Calvert Islands, though Krunsenstern thinks that these are the same as the Ralick chain. It is not of much importance, in a geographical point of view, whatever it might be for the benefit of navigation.

The small size of Kotzebue's vessel gave him the advantage of sailing through the openings in the circular reefs, and of examining the lagoons within them. From his account, it would seem that the coral-making animals do not commence their labours at the very depth of the ocean, as has been supposed, but on rocky shoals, the summits, in all probability, of submarine mountains, round which they lay the foundation of their extraordinary fibres, forming an united chain, irregular in shape, but generally approaching, more or less, to a circle. The greatest depth at which they are able to derive a sufficient degree of light and heat for their operations has not yet been ascertained; but we know that marine animals have been drawn up in a living state from the depth of a thousand fathoms, and from a temperature very little above that of the freezing point. The outer edge of the reef exposed to the surf of the sea is the first that shows itself above water; in process of time, it becomes indurated, breaks, and crumbles, by the action of the sea, and at length forms a sort of barrier, within the sloping sides of which the living animals are seen carrying on their operations. Those observed by Chamisso were the *Tubipora musica*, the *Millepora cærulea*, *obstichopora*, *actimas*, and various kinds of the polypus. He found the living branches of the *lythophytes* generally attached to the dead stems; many of the latter, however, crumbled into sand, which, accumulating on the inner declivity, constitutes no inconsiderable part of the surface of the new islands, which rise out of this reef, and are gradually united into one island, having in its centre a salt water lake, that alternately grows up by a silent and slow progress, till what was at first a chain of islets, has become one connected mass of land. The progress towards a state fit for the habitation of man is thus described by Chamisso:—

"As soon as it has reached such a height, that it remains almost dry at low water, at the time of ebb, the corals leave off building higher; sea-shells, fragments of coral, sea-hedgehog shells, and their broken off prickles, are united by the burning sun, through the medium of the cementing calcareous sand, which has arisen from the pulverization of the above-mentioned shells into one whole or solid stone, which, strengthened by the continual throwing up of new materials, gradually increases in thickness, till it at last becomes so high, that it is covered only during some seasons of the year by the high tides. The heat of the sun so penetrates the mass of stone when it is dry, that it splits in many places, and breaks off in flakes. These flakes, so separated, are raised one upon another by the waves at the time of high water. The always active surf throws blocks of coral (frequently of a fathom in length, and three or four feet thick) and shells of marine animals between and upon the foundation stones; after this, the calcareous sand lies undisturbed, and offers to the seeds of trees and plants, cast upon it by the waves, a soil upon which they rapidly grow, to overshadow its dazzling white surface. Entire trunks of trees, which are carried by the rivers from other countries and islands, find here, at length, a resting place, after their long wanderings: with these come some small animals, such as lizards and insects, as the first inhabitants. Even before the trees form a wood, the real sea-birds nestle there; strayed land-birds take refuge in the bushes; and, at a much later period, when the work has been long since completed, man also appears, builds his hut on the fruitful soil, formed by the corruption of the leaves of the trees, and calls himself lord and proprietor of this new creation."

In the Southern Hemisphere.

Friendly Islands.

1. *The Friendly Islands.*—The Friendly Islands, among which may also be included the Feejee Islands, were first discovered by Abel Jansen Tasman in 1643, to three of which he gave the names of Amsterdam, Middleburgh, and Rotterdam. The first of these islands is that which was afterwards visited by Captain Cook, and described by him under the name of Tongataboo; more properly, as we since learn from Mr Mariner, *Tonga*, the annexed word *Tabboo*, so extensively used throughout Polynesia, being expressive only of its sacred character. From the inhabitants of this island Tasman received yams, cocoa-nuts, bananas, hogs, and fowls, in exchange for iron, nails, beads, and pieces of linen. They had also plenty of sugar-canes. Women as well as men swam off to the ship, and it was observed that all the elder dames had the little finger of both hands cut off, but the young women had not. They wore round the middle a covering of mat-work, which reached down to their knees; the rest of the body naked. None of the

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men would taste wine, and they were ignorant of the use of tobacco; they had no arms of any kind, which led Tasman to conclude that they lived in perpetual peace and friendship.

Produce of the Islands, and the Natives.

Tasman next touched at Ammomooka, or, as he called it, Amsterdam Island, in the hope of meeting with better water than on the first, where it was bad and scanty. On landing, they perceived some sixty or seventy persons sitting quietly on the shore, who had no arms of any kind, and appeared to be a harmless and peaceable people. There were, besides, many women and children, the former clothed like those on Amsterdam Island, but they were of a larger size, and as strong in their bodies and limbs as the men. The party was shown to a piece of fresh water not a mile from the shore, about a quarter of a mile in circumference, and about a musket-shot from the north side of the island, where there was a good sandy bay. Here they watered their ships, and received abundance of provisions, the same in kind as those of the other island. The inhabitants are described as being great thieves, but very friendly. They have large vessels with masts, sails, and outriggers, as well as canoes, and on going into the interior of the island it was observed that all their plantations were laid out in neat and regular order. "In our walk," says Tasman, "we saw several pieces of cultivated ground or gardens, where the beds were regularly laid out into squares, and planted with different plants and fruits; bananas and other trees placed in straight lines, which made a pleasant show, and spread round about a very agreeable and fine odour; so that among these people, who have the form of the human species, but no human manners, you may see traces of reason and understanding." He says they have no religion, no idols, relics, or priests; but that they have their superstitions, as a man was seen to take up a water-snake, which, after placing it respectfully upon his head, he threw back into the water. Indeed, they seem averse from hurting any thing that has life, for though the flies are numerous and troublesome, they will not kill them, and one of the principal people was offended on perceiving the steersman kill a fly, though accidentally. Captain Cook bears testimony to the beauty and fertility of the Tonga Islands. "There was not," says this celebrated man, "an inch of waste ground; the roads occupied no more space than was absolutely necessary; the fences did not take up above four inches each, and even this was not wholly lost, for in many were planted some useful trees or plants. It was everywhere the same; change of place altered not the scene; nature, assisted by a little art, nowhere appears in more splendour than here." The missionaries, too, in 1797, found these islands in as high a state of cultivation and beauty as they appeared to Tasman and to Cook.

Revolution in the Government.

A woeful difference in their peaceable habits, according to Mr Mariner, has taken place since the visits of these Europeans. In 1799 a revolution took place, and from that time bloody wars and most savage slaughter have desolated these beautiful islands. They first commenced, as it would appear, by a most atrocious savage, in whom the kingly power was vested, who not only practised the most barbarous cruelties on his subjects, but seized upon the sacred or ecclesiastical power, which had always, as in Japan, been kept separate from the secular arm. The sacred spell being thus broken, which rested solely on public opinion, a complete revolution followed, and from that hour these once happy islands have been the scene of slaughter, famine, and every species of horror and misery. We must not, however, give implicit credit to all that has been stated by Dr Martin, the writer of Mariner's account of these islands, but rather consider it as a romantic exaggeration of facts and descriptions, similar to that of the Pellew Islands by Mr Keats. There are shades of difference merely between the inhabitants of these and of the neighbouring islands.

2. *Navigator's Islands.*—To the north-east of the Feejee, Tonga, or Friendly Islands, are situated the Bauman or Navigator's Islands. The first name was given to them after Captain Bauman, of the Teinhoven, by Jacob Roggewein, by whom they were discovered in 1722; the latter name was conferred by Bougainville, who passed them in 1768. La Perouse likewise visited these islands, and is of opinion that they are not the same as Bauman's Islands, because their geographical position does not agree with that assigned to them by Roggewein. Burney, however, has no doubt that they are identical, the only difference being in their supposed longitude, which, in the time of Roggewein, was frequently set down erroneously by several degrees.

Description of the Islands and Natives.

These islands form an archipelago, consisting of ten in number, according to La Perouse, of which Maouna, Oyolava, and Pola, are the largest and most beautiful. The parallel of 14° south latitude, and the meridian of 190°, pass through the centre of the group. They are said by La Perouse to be volcanic, but surrounded by coral reefs. Roggewein describes the hills and valleys as affording a delightful prospect. The natives came off in boats neatly made and carved, bringing fish, cocoa-nuts, and plantains. They are said to have white skins, but tanned by the sun, gentle in their manners towards each other, lively and good humoured; their bodies were neither painted nor marked, and they were clothed from the waist downwards; the cultivated grounds were all enclosed, and, in short, they are described by the writer of Roggewein's voyage as the most civilized and honest people they had met with among the islands of the South Sea. We may conclude, indeed, from his account, that they were equally well cultivated, and the inhabitants equally mild and peaceable with those of the Friendly Islands.

Navigator's Islands.

Very different, however, is the account given of them by La Perouse. Ferocious in the highest degree, he describes them as utterly destitute of gratitude and every good moral feeling; that a look of disdain is stamped on all their countenances, and that they are eternally fighting with each other, so that their bodies are covered with scars occasioned by the blows of clubs. Tall in stature, their limbs are of colossal proportions; and their bodies are tattooed to such a degree as to make them appear clothed, though they have only a girdle of sea-weeds round their loins, which reaches to the knee. The

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size of the women corresponds with that of the men, and their whole behaviour is represented as highly indecent and disgusting. They had no desire for iron, preferring their own adzes and other tools made of basalt. Their huts were made with great nicety, and all their wood-work was highly polished and carved. Their matting and cloth were exceedingly beautiful; the latter woven with thread made from the nettle, and a species of flax. The sails of their boats or canoes were made of this cloth. The islands are so intersected with creeks, that they travel from place to place almost universally in canoes, which have outriggers to prevent them oversetting.

Fertility.

All the islands were clothed with trees up to the very summit of the hills, many of them laden with fruit. The villages are ranged along the margin of the streams which fall from the mountains, and are built in the midst of groves of cocoa, banana, guava, and other fruit trees common to the South Sea islands. The woods abound with wild pigeons and turtle doves, which are tamed by the natives, and kept about their houses in flocks of many hundreds. Sugar-cane grows abundantly and without culture. Their animals are pigs, dogs, and the domestic fowl; these and the fish, which they catch with great expertness, afford them an abundant supply of food.

Society Islands.

3. *Society Islands.*—The first account of these islands is given in the voyage of Jacob Roggewein, who touched at Ulietea in the year 1722; at least it is conjectured by Burney on probable grounds, that the Verquickking or Recreation Island of that navigator is the same. On sending a boat on shore, the inhabitants assembled on the beach, and advanced into the water armed with lances to oppose their landing. The Hollanders fired upon them, and having dispersed them, landed on the beach, and the inhabitants returned in a friendly manner, and brought them cocoa-nuts and other articles of food. The Hollanders then advanced up a valley towards the mountains, but some thousands of the natives coming out of the glens and crevices, made signs to them to return. The Hollanders, however, paid no regard but proceeded, upon which showers of stones were hurled at them, by which some were killed and others wounded. These volleys were answered by a discharge of musketry, which killed many of the islanders, who, nevertheless, continued the action, and finally drove the Dutchmen into their boats. Many of the latter subsequently died of the wounds they had received in consequence of the bad state of their constitutions, being severely affected with the scurvy.

Description.

Captain Cook visited these islands in 1769, and again in 1777. They consist of six in number (besides small coral islets), whose names are Ulietea and Otaha (both encompassed by the same coral reef), Huaheine, Bolabola, Tubai, and Maurua. They extend from about 16° to 17° south latitude, and from 151° to 152° west longitude. The climate, the productions, and the inhabitants, resemble so nearly those of Otaheite, that the same description will apply to both. The surfaces of all the islands are uneven and hilly, but not mountainous, and the hills are finely wooded. The inhabitants, like those of the Navigator's Islands, are generally of a larger stature than the Otaheitans. The late Sir Joseph Banks measured one of the natives of Huaheine, and found him to be six feet three inches and a half in height, and the women are described as generally more handsome and somewhat fairer than those of Otaheite. Bolabola differs from the rest of the islands by having a lofty double peaked mountain near its centre, apparently volcanic. In Ulietea there is a large morai, in which a number of jaw-bones are kept as trophies of war. The coral reefs which every where surround these islands form numerous safe and commodious harbours for shipping, and refreshments of hogs, fowls, plantains, cocoa-nuts, and yams, are generally to be had in great abundance.

The Georgian Islands.

4. *The Georgian Islands, including Otaheite, &c.*—Otaheite is the chief island of this vast group, which extends over fifteen degrees of longitude, in the direction of south-east. The extreme point is Pitcairn's Island, lately become interesting on account of the discovery of the descendants of the mutineer Christian and some of his associates. The natives of this vast chain of islands, and particularly of Otaheite, may probably be considered as the most civilized, but, at the same time, the most sensual people in all Polynesia. It was first discovered by Quiros, in 1606, and received from him the name of Sagittaria. The natives received the strangers with great kindness, gave them cocoa-nuts and other fruits, and a general interchange of civilities and presents soon took place. This good understanding remained uninterrupted, and the Spaniards, for once, left the island without having quarrelled with the inhabitants. In their zeal, however, they committed an act which, if discovered, might have been attended with unpleasant circumstances. The place at which they first landed was uninhabited, but in passing through a wood they discovered a Morai, in which they concluded "the enemy of mankind resided;" and under this impression, cut down a tree, which they formed into a cross, and planted in the midst of the sacred building.

In 1765, Commodore Byron discovered two low islands to the northward of Otaheite, which, in honour of his Majesty, he named George's Islands, one of which, afterwards visited by Cook, is called Tiookea; the natives of these islands were very dark coloured, robust, and apparently ferocious; their bodies were marked with the figure of a fish.

In 1767, Captain Wallis touched at Otaheite, and went through the ceremony of taking possession of the island in the name of his Sovereign; but the flag was removed by the natives in the night. Various squabbles occurred between the seamen and the natives, who, however, behaved on the whole with great kindness and hospitality. Most of the quarrels were owing to the licentious intercourse of the seamen with the native women. In 1768, M. de Bougainville visited Otaheite, and was most hospitably received; in return for which, several murders were committed by the French seamen. Captain (then Lieutenant) Cook anchored in Matavai Bay in April 1769. It is from this and his several subsequent visits, together with a missionary voyage in the ship

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Duff, commanded by Captain Wilson, 1796—1798, that Otaheite is so well known to us.

Otaheite.

The island consists of two peninsulas, connected by a low isthmus, about three miles in width, covered with brushwood. The larger, Otaheite Nove, is about ninety miles in circumference, and nearly circular; the smaller, Tiaraboo, is about thirty miles; the whole nearly surrounded by a low belt of land, from a furlong to a mile in width, which is prolonged by a gradual rise to the valleys which run up to the foot of the lofty central mountain. These valleys and their intermediate ridges are beautiful, clothed with a great variety of trees to their very summits; in the valleys are mostly met with clear streams of water, which, in the rainy season, become mountain-torrents. The island being surrounded with coral reefs, is dangerous to approach, and the only safe harbour is that of Matavai, on the northern side, in latitude 17° 30′ S. longitude 149° 13′ W. This too is not free from danger, from December to March. The climate is delightful, the thermometer seldom rising above 80° in summer, and ranging from 62° to 72° in winter.

Productions.

The island is so fertile as to produce every thing in abundance, and without toil, for the sustenance of man. The bread-fruit is here superior to that which grows on the other islands. The fruit affords them a most nutritive food, either for present use, or made into a paste called *mahie*, which will keep till the following season; the trunk supplies them with timber for their buildings and canoes; it exudes a gum, which serves for pitch, and from the inner bark is manufactured a substantial cloth. They reckon no less than thirty varieties of this most useful tree, which, with the different exposures to the trade winds, and the difference of elevation above the sea, afford to the natives a bread-fruit harvest at almost all seasons of the year. The cocoa-nut, next to the bread-fruit, supplies them with meat, drink, cloth, and oil. Of plantains, they reckon fifteen different sorts. Yams and sweet potatoes, tarro-root of different kinds, and various other edible roots and fruits, are most abundantly produced; to which our missionaries have added the pine-apple, the grape, and various culinary vegetables of Europe; but the natural and spontaneous productions of the soil, and the consequent indolence of the people, are unfavourable to their success.

Animals.

The animals found on the island are hogs, dogs, and rats. Several attempts have been made to introduce the horse and horned cattle, sheep and goats, but without success. The latter are so disliked for their smell and the mischief they did to their plantations, that they drove them into the mountains, where they run wild. The breed of cats has succeeded, and found to be extremely useful; and rabbits have been introduced, but we know not with what success. Common poultry are abundant, and the woods supply vast quantities of wild pigeons and parrots. The tropic-bird builds its nest in the steep cliffs, and as their long feathers are highly valued, they are taken on the nest by lowering down a man seated across a stick, by a rope, to the depth of thirty or forty fathoms; in which situation, by means of a long pole, he swings himself from side to side, examining all the holes as he descends, in order to take the bird on her nest. The shores abound with sea fowl, and the sea with excellent fish, which they take with great expertness by hook and line, or by the net. Dolphins are caught at a distance from the shore, by baiting the hook with a real or artificial flying fish. Their fishing-tackle displays the greatest ingenuity, and can only be exceeded by their skill in using it. Their hooks are made of pearl-shells, bone, and hard wood. The coast abounds with lobsters, crabs, and various kinds of shell-fish.

Inhabitants.

The colour of the natives is that of olive, or light copper. The men are above the middle size; the chiefs almost uniformly tall, muscular, and well-limbed, measuring from five feet nine inches to six feet four inches, and continue healthy and vigorous to a good old age. The women of the upper ranks are also tall, with limbs finely turned. Their skins soft and delicate; eyes black, sparkling, and full of expression; teeth beautifully white and even; their hair jet black, and generally ornamented with flowers; in their gait they are firm, but easy and graceful. From a custom of compressing the face when infants, they can scarcely be called beauties; yet, according to the account of Captain Wilson, they possess feminine graces in an eminent degree; "their faces never being darkened with a scowl, or covered with a cloud of sullenness or suspicion." They are affable and engaging; mild, gentle, and unaffected; courteous to each other and to strangers. The whole of the body to the middle of the leg is clothed; but there is a singular custom which compels a woman to uncover her shoulders and breasts in the presence of a chief, or in passing a morai, or sacred place. The lower classes have always been described as extremely licentious, but Captain Cook says they have been much calumniated. "It is too true," say the writers of the Missionary Voyage, "that, for the sake of gaining our extraordinary curiosities, and to please our brutes, they have appeared immodest in the extreme. Yet they lay the charge wholly at our door, and say the Englishmen are ashamed at nothing, and that we have led them to public acts of indecency never before practised among themselves." It must be admitted, however, that the most abandoned conduct is freely indulged by the women of the Arreoy society, who, to the crime of unbounded licentiousness, add that of murdering their children the moment they are born. In recent accounts, however, it is stated, that this horrible practice has been abolished, and that Christianity is making a rapid progress among these interesting islanders.

As wives, the Otaheitan women are tenderly affectionate to their husbands and children, nursing and attending the latter with the utmost care. They never, on any occasion, strike a child. A melancholy instance of the fidelity and affection of one of these women is given in the *Missionary Voyage*. "The history of Peggy Stewart marks a tenderness of heart that never will be heard without emotion. She was daughter of a chief, and taken for his wife by Mr Stewart, one of the unhappy mutineers (of the Bounty). They had lived with the old chief in the most tender state of endearment; a beautiful little

girl had been the fruit of their union, and was at the breast when the Pandora arrived, seized the criminals, and secured them in irons on board the ship. Frantic with grief, the unhappy Peggy flew with her infant in a canoe to the arms of her husband. The interview was so affecting and afflicting, that the officers on board were overwhelmed with anguish, and Stewart himself, unable to bear the heart-rending scene, begged she might not be admitted again on board. She was separated from him by violence, and conveyed on shore in a state of despair and grief too big for utterance. Withheld from him, and forbidden to come any more on board, she sunk into the deepest dejection; it preyed on her vitals,—she lost all relish for food and life,—rejoiced no more,—pined under a rapid decay of two months, and fell a victim to her feelings, dying literally of a broken heart."

The Otaheitans are generous even to a fault; they seem to be utterly unable to resist importunities, and always ready to share their last morsel with their neighbours. Poverty is no reproach, but affluence with covetousness brings contempt on the owner. Should any one, indeed, refuse to share his property in cases of distress, the chances are that it will be destroyed, and his house pulled down over his head. The office of king is hereditary in one family; the chiefs resemble our ancient barons; under them are the vassals, and below them the *villeins*, or labourers. The king and queen enjoy many privileges, one of which is, to be carried about every where on men's shoulders; and the reason of this is, that whatever soil they tread upon becomes sacred, and belongs to them; so also, if they enter a house, it is rendered sacred, and becomes their property. Their domestics and attendants are also *raa*, or sacred, and for thieving, plunder, and all manner of licentiousness, they are said to be the worst on the island.

In the *Missionary Voyage* is given an account of the ceremony of investing the new sovereign with the royal *maro*, when each chief of the island, amounting to nearly one hundred, brings one, two, or three human victims, to offer up on the occasion. They are brought before the sovereign in a lifeless state, having first been stoned to death, or knocked on the head with clubs. From each of these victims the priest scoops out an eye, and presents it to the king on a plantain-leaf, and the bodies are then carried away and interred in the Morai. The reason assigned for this oblation is, that the head being accounted sacred, and the eye the most precious part, it is presented to the king as the head and eye of the people. During the presentation the king holds his mouth open, as if devouring it, whereby it is imagined he receives additional wisdom and discernment. The royal *maro*, and the sacred canoes which brought the human sacrifices, are then deposited in the Morai. A series of feasts then begin, which continue for two months. These abominable rites, if not entirely abolished, have, in a great degree, ceased by the influence of the missionaries.

In their language and their deities may be traced their Hindoo origin; and, though their religion is a tissue of superstitions and brutal ceremonies, they never draw near to their Eatova with carelessness and inattention. Captain Cook testifies to the decorous conduct of an Otaheitan on such occasions: "He is all devotion,—he approaches the place of worship with reverential awe,—uncovers when he treads on sacred ground, and prays with a fervour that would do honour to a better profession."

On the whole, the Otaheitans are not only the most advanced in civilization, but inhabit the fairest and most fertile island of Polynesia. Taking into account, as Captain Wilson says, its amenity, the salubrity of the climate, the plenty of fine water, spontaneous productions of the earth, the rich and most romantically picturesque appearances of the country, "he felt the justice of the title given to Otaheite by one of the navigators, as the 'Queen of Islands.'" The latest accounts received from the missionaries are most gratifying. One of them thus concludes: "Public immorality, drunkenness, and profane swearing, are unknown here. All their former sports and amusements are completely put down. Their *morais* are almost all demolished, and many of them completely obliterated; and it is a singular fact, that chapels now occupy the very ground on which many of them stood."

With such a people is the north-western extremity of the large group of islands, and the interesting offspring of the mutineers of the Bounty, who still preserve their religious habits and purity of manners, on the small island of Pitcairn, at the opposite extremity, a hope may be indulged that, in the course of half a century, civilization will have made a rapid progress, not only throughout the Friendly, Society, and King George Islands, but over a very considerable portion of Polynesia.

5. *The Marquesas.*—This cluster of islands was discovered by Alvarode Mendana in 1595, and named by him Las Marquesas de Mendoça, in honour of the Viceroy of Peru. Four only are described by Quiros the pilot, under the names of La Dominica, Santa Christina, San Pedro, and La Madalena. The Spaniards anchored in a port on Santa Christina, to which they gave the name of Madre de Dios, well protected from the trade-wind, and which has two excellent streams of fresh water flowing into it. The people are described as being an elegant race, the women in particular as remarkably beautiful, whose complexions and general appearance are said to excel those of the women of Lima. Their dress consisted of a cloth made of the leaves of a palm-tree, with which they were covered from the breast downwards; and so civilly disposed were they, that a beautiful native woman seated herself by the side of Donna Isabel, the wife of Mendana, and began to fan her. But the Spaniards, as usual, found means to quarrel with the natives, and to drive them with their fire-arms into the woods.

The Marquesas.

The produce of the island was hogs, fowls, fish, cocoa-nuts, sugar-canes, plantains, and the bread-fruit, described for the first time by the writer of this voyage.

Subsequent discoveries have made us nearly as well acquainted with the Marquesas as with Otaheite. Captain Cook visited them in 1774, and Captain Wilson in 1797. From these we know that they consist of eight islands in number, besides some smaller islands to the westward, which being seen by

Description.

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an American master of the name of Ingraham, he called them Washington's Islands. They had previously been seen, however, by Marchand in 1789, and may fairly be grouped as part of the Marquesas. The centre of the group may be reckoned in about the latitude 9° 30′ south, and longitude 139° 30′ west.

Manners.

The manners, the religious ceremonies, the marais, and the general appearance of the natives, are so similar to those of Otaheite, that a description of them would amount to little more than a repetition of what has been said. They have all the good qualities of the natives of that island, and most of their bad ones; but owing probably to a more restricted communication with strangers, a greater degree of simplicity was observable in their manners, on the first arrival of the missionaries among them, than in the people of Otaheite. Scarcely had they anchored in Resolution Bay (Madre de Dios), than two women, though dark, swam off to the ship, in the hope of meeting a favourable reception, calling out in a piteous tone, when they found they could not be admitted on board, "*Waheené, waheené!*" We are women, we are women. The next morning the visit was repeated, and is thus described in the *Missionary Voyage.*

"Our first visitors from the shore came early; they were seven beautiful young women, swimming quite naked, except a few green leaves tied round their middle; they kept playing round the ship for three hours, calling *Waheené!* until several of the native men had got on board; one of them, being the chief of the island, requested that his sister might be taken on board, which was complied with. She was of a fair complexion, inclining to a healthy yellow, with a tint of red in her cheek, was rather stout, but possessing such symmetry of features, as did all her companions, that as models for the statuary and painter their equals can seldom be found." Captain Wilson says, that an Otaheitan woman which they had on board was far eclipsed by the Marquesan woman; but she was shocked to see a woman quite naked walking the deck, and threw over her a dress of Otaheitan cloth; but as for the rest of these females, the goats, it seems, soon stripped them of their green leaves, and left them in a state of complete nudity. On shore the women clothe themselves in decent habits.

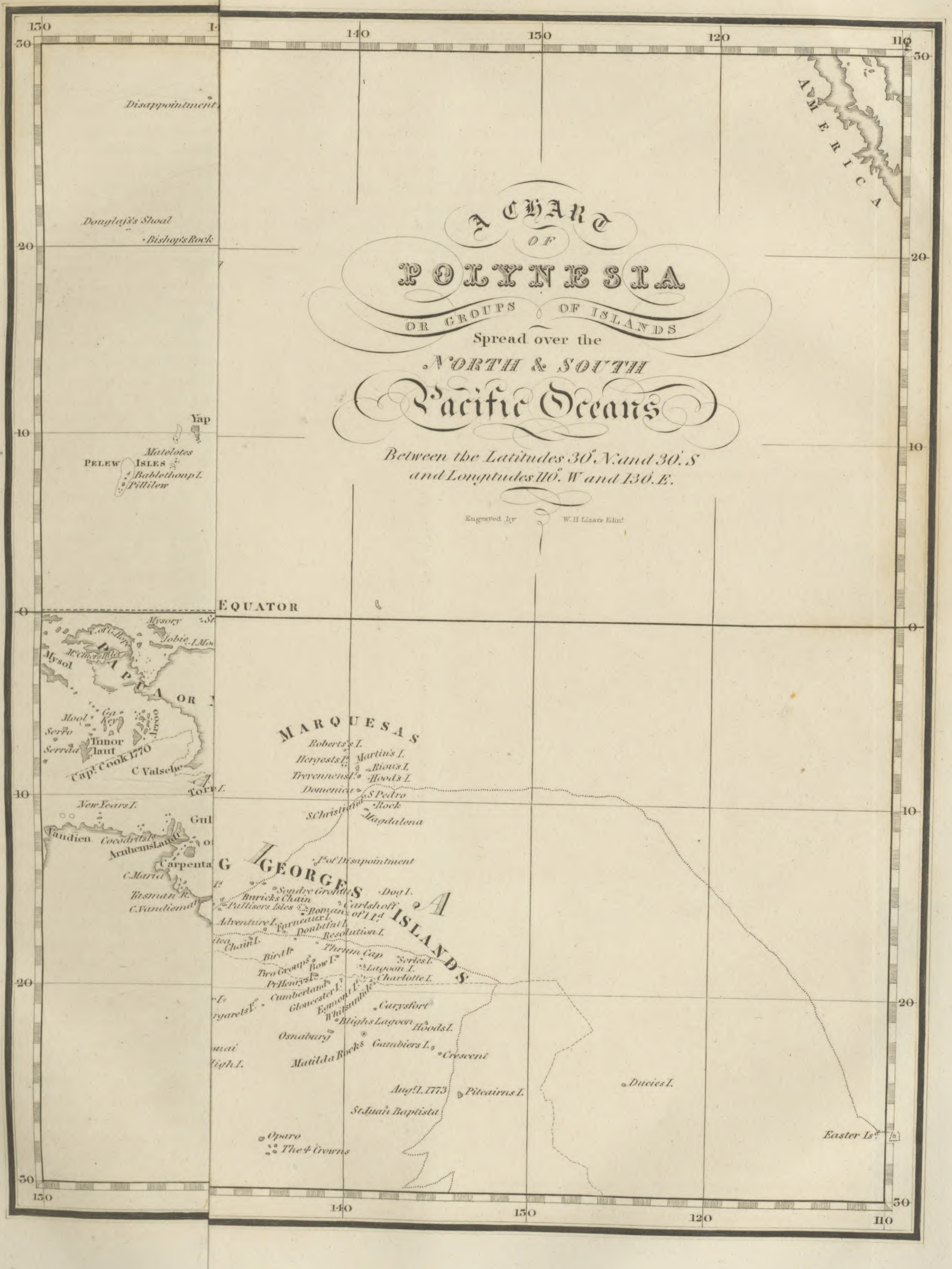
The Marquesans are so far superior to the Otaheitans, that they sacrifice hogs only to their deities, and never men. Their houses, canoes, their dress, and the cultivation of their land, are at least equal to those of Otaheite, and they have none of those infamous *arreoy* societies. Captain Porter of the American frigate Essex, after brutally massacring a number of these people on the most frivolous pretext, charges them with cannibalism, though, from his own account, there does not appear the slightest ground for so injurious an imputation. To all unprejudiced navigators they have appeared as an amiable people, entertaining a great respect for old age, fond of their children instead of murdering them, as on Otaheite and some other islands, and living in peace and harmony with each other, and with their families.

Easter Island.

6. *Easter Island.*—This small island, not 30 miles in length, is only deserving of notice from its solitary position, its great distance from any of the islands of the Pacific, its comparative proximity to the coast of South America, and its being inhabited by a race of men who differ no more from the rest of the Polynesians than they do from each other; having the same language, the same features, the same religious notions, and Morais constructed as they generally are in other islands; on the platforms of which are erected shapeless and uncouth masses of stone, carved in imitation of the human bust, with rude faces four or five feet long, set on trunks of ten or twelve feet in height. Kotzebue, the last visitor to this island, looked, however, in vain for any traces of these statues on the spots where they are described by Cook and La Peyrouse.

This island is supposed to have been discovered by the Buccaneer Davis in 1687; though some have contended for the Dutch Admiral Roggewein being the discoverer, who gave it the name of Paaschen, or Easter Island, having first seen it on the day of that feast. Its latitude is 27° 5′ south, and longitude 109° 46′ west.

It is not remarkably fertile; few trees are found on it, and no running stream. The natives are very industrious in raising food for their support, which consists chiefly of bananas, taro-root, sugar-canes, sweet potatoes, and yams. By some navigators they are described as a very savage people, by others as a mild and amiable race:—the fact is, that their conduct has corresponded with the treatment they have received from strange visitors. Thus their decided hostility to Kotzebue, when he attempted to land on the island, was explained on his arrival at the Sandwich Islands. An American commanding a schooner called the Nancy from New London, had observed a vast multitude of seals on the shores of the small uninhabited island of Massafuero, to the westward of Juan Fernandez; and thinking it might turn out an excellent speculation, if a small establishment were formed on the island, to carry on the fishing, set about the means of carrying this project into effect. His own crew was but just sufficient to navigate the vessel, and there being no anchorage off the island, could not be spared to catch seals. The brutal wretch, therefore, proceeded to Easter Island, and landing at Cook's Bay, seized and carried off twelve men and ten women to people his new colony. For the first three days they were confined in irons, and were not released till fairly out of sight of land, when the first use they made of their liberty was to jump overboard, choosing rather to perish in the waves than to be carried away they knew not whither, or for what purpose; the women, who were with difficulty restrained from following them, were carried to Massafuero, but what ultimately became of these poor creatures M. Kotzebue does not relate. No wonder then that such base and inhuman practices should drive the natives to acts of hostility against all foreign intruders. (K.)



A CHART OF POLYNESIA OR GROUPS OF ISLANDS Spread over the NORTH & SOUTH Pacific Oceans
Between the Latitudes 30° N. and 30° S and Longitudes 110° W and 130° E.
Engraved by W.H. Lizars Edin.
AMERICA
EQUATOR
MARQUESAS
GEORGES ISLANDS
Disappointment I.
Douglas's Shoal
Bishop's Rock
Yap
Matelotes
PELEW ISLES
Bablethoup I.
Pillilew
Mysory
Jobie
Mysol
PAPUA OR
Mool
Serro
Serraa
Timor laut
Capt. Cook 1770
C Valsche
New Years I.
Vandien
Cocodrils I.
Arnhems Land
Carpenta
C. Maria
Tasman R.
C. Vandieman
Roberts's I.
Hergests I.
Martin's I.
Trevennens I.
Rious I.
Hoods I.
Domenica
S. Pedro
Rock
S. Christina
Magdalena
I. of Disapointment
Dog I.
Buricks Chain
Pallisers Isles
Carlshoff
Adventure I.
Furneaux I.
Resolution I.
Chain I.
Bird I.
Thrum Cap
Two Groups
Bow I.
Lagoon I.
Charlotte I.
Pr. Henrys I.
Cumberland I.
Gloucester I.
Egmont I.
Whitsunday I.
Carysfort
Blighs Lagoon
Hoods I.
Osnaburg
Gambiers I.
Crescent
Matilda Rocks
Aug. I. 1773
Pitcairns I.
Ducies I.
St. Juan Baptista
Oparo
The 4 Crowns
Easter Is.

Published by A. Constable & Co. Edinr. 1822

POOR-LAWS.

Poor-Laws.

THE laws comprehended under this title, and regulating the relief, maintenance, and employment of the poor, form so important and peculiar a feature in the polity of England, as to demand a careful notice. Especially as the administration of the system, within the last twenty-five years, has been so essentially altered, as to render any previous account, in a great measure, obsolete: and the effects of the system have been so widely extended, and so sensibly felt, as to obtain a considerable degree of public attention.

We shall, therefore, under this article, explain, as briefly as possible, the laws on which the English Poor-System is founded; their practical administration; their effects political and moral; and the principal plans which have been proposed for the mitigation and ultimate removal of the evils inseparable from a system of compulsory and indiscriminate relief, involving an interference with the general concerns of a large portion of the community.

Origin of the Poor-Laws.

It is not necessary to trace, particularly, the circumstances of difficulty and hardship, to relieve which the compulsory provision for the poor was first instituted. From the date of the earliest statutes, the middle of the sixteenth century appears to have been the period when the number and wants of the poor began to attract legislative attention. In 1536, 1550, 1561, and 1563, sundry statutes were passed directing that every aged, disabled, and impotent person, should be relieved and kept in the place where they were born or had dwelt three years; and in the last of the acts referred to, the justices of the peace were empowered to make the payment of assessments for these purposes compulsory. The sudden alienation of the abbey-lands, the cessation of all customary relief from the monasteries, together with the rapid increase in the money price of commodities, occasioned by the influx of the precious metals from America (estimated at 50 *per cent.* between the years 1550 and 1580), sufficiently account for the pressure on the labouring classes which these provisions were intended to remove.

However, in spite of all palliations, this evil grew, and led to the famous act of the 43d of Elizabeth, which continues to this day the fundamental and operative law on this important subject. This statute enacts, "That the churchwardens and overseers shall take order from time to time (with the consent of two or more justices) for setting to work the children of all such whose parents shall not be thought able to keep and maintain their children; and also, for setting to work all such persons, married or unmarried, having no means to maintain them, and using no ordinary or daily trade to get their living by; and also, to raise by taxation, &c., a convenient stock of flax, to set the poor on work; and also competent sums of money for and towards the necessary relief of the lame, impotent old, blind, and such other among them, being poor and not able to work."

Poor-Laws.

Results of the Act of Eliz. 43.

By this enactment, the State virtually undertook to do two things, which were never before attempted by any national or legislative provision. It became pledged to support, at the public expence, all the poor, aged, and impotent members of the community; and, far worse, to provide employment for all those who would not or could not procure it for themselves.

The first of these undertakings, however humanely designed, is found by experience to eradicate some of the finest principles of human nature, and to create more distresses than it remedies.

The second, which compels the overseers to set to work all those for whose labour there is no natural demand, is in decided opposition to the known rules of political economy. The number of persons that can be employed in labour must absolutely depend upon the amount of the funds applicable to the maintenance of labour; so that, an enactment, engaging to find employment for as many as may demand it, undertakes a condition which it is not in the power of any law to fulfil.

The wonder which arises at the first view of a system like this—a system which has the radical fault of assuming, or establishing, the right of the poor, *i. e.* as it may turn out, of the whole community, to support, at the expense of the community, is, that it should have existed more than 200 years, without occasioning the complete destruction of prosperity. This, however, is no proof of the innocence of the law; it results from the mode of its execution and administration. When persons were only relieved in their own parishes, and when relief was only to be had by application to an overseer, and often, of course, distributed in a capricious and insulting manner, few would seek it who could possibly subsist otherwise, and a becoming spirit of independence diminished the number of claimants. But above all, it was ordered by the law that the idle should be set to work, and the paupers maintained *in workhouses.* Accordingly, workhouses existed in all large towns; in most considerable villages, and in some districts, where the parishes were small, a common workhouse was established by the union of several neighbouring parishes. Nothing could render these receptacles a comfortable abode, except the wisest management and most vigilant inspection. But few persons capable of adequately discharging such an office would undertake so unpromising an employment. All ages, and all characters,—the orphan or the illegitimate child; the prostitute female, the idiots of the parish, the idle vagabond, whom no master would take the trouble to reclaim; the aged widow and the decrepit labourer; the most pitiable members of society, and those who had the least claim to compassion, were crowded into one comfortless home, and joined their quarrels, their com-

Administration of the Law up to 1795.

plaints, and their sorrows together. Those who had any sense of comfort or decency, would submit to the severest privations rather than obey the threatened alternative, and *go to the workhouse.*

So that, twenty-five or thirty years ago, the expenses arising from the poor-laws were, in a great measure, confined to the maintenance of workhouses; and the workhouses were a resource for the aged, destitute, and impotent; a place of restraint for the idle and disorderly, and an object of terror to the able and industrious. The out-door relief was not extended beyond occasional assistance during temporary illness, or the woman's confinement; or beyond the payment of a part of the rent of the cottage in cases of large families; or a small weekly allowance to a few infirm persons of good character, who made up the rest of their support, by such trifling works of industry as they were able to perform. Some encroachments, no doubt, took place from time to time, and in peculiar situations, on these general principles of public relief; but no man in health and in work ever thought of applying for parochial pay: and as artificial encouragement had not yet disturbed, in any material degree, the general adaptation of the supply to the demand for labour, want of work was not a common case. Thinking people, it is true, even then foresaw that the principle of the poor-laws was fundamentally wrong, and had a tendency to create the distress which it professed to remove; and particularly, they argued, that the idea of providing employ at the public expense was contrary to every sound rule of justice and policy. But, in fact, this part of the act of Elizabeth had not then been called into extensive operation, and went little further than the wholesome purpose of keeping those employed who were collected in workhouses; while the discipline, the disgrace, and the misery of the workhouse itself, acted the useful part of stimulating industry, and encouraging independence, as long as the alternative of entering it, or of providing independent support, was left by the Legislature, enforced by the parish, and required by the magistrate.

Notwithstanding these checks, however, to the natural consequences of the system, the assessment to the poor is found to have progressively increased at every period for which returns have been preserved. The average sum applied to the relief of the poor for the years 1748, 1749, 1750, was L. 690,000 *per annum*. In 1776 it amounted to L. 1,531,000, an increase far beyond what the rise in the prices of corn would justify; * in 1783-4-5, to L.2,000,000, though the average price of corn had fallen during the nine intermediate years: † so that such gradual increase, in spite of all obstacles, and without any sufficient external cause, can only be attributed to the known tendency of regular and indiscriminate charity to create its own objects.

New Mode of Administration since 1795.

But in the year 1795 a change took place in the administration of the poor-laws, which has completely altered the state of the country. This was a winter of unusual scarcity. The price of corn *per* quarter, which for the three preceding years had stood at L. 2, 14s., averaged more than L. 4 during the whole of 1795 and 1796. As the returns of labour could not be expected to keep pace with such a sudden rise in the necessaries of life, distress was universal; and there appeared as claimants for parochial relief not only the infirm and aged, but the able-bodied and industrious, who had few of them ever before resorted to the parish, and that only during temporary illness and disability. It was at this season of acknowledged difficulty that the county magistrates, first in Berkshire, and afterwards in other parts of the middle and south of England, agreed to relieve the poor according to a fixed and uniform scale, regulated by the price of bread; and issued a table, which professed to show, at one view, what *should be* the weekly income of the labouring poor, which it fixed in a certain ratio, according to the price of bread, and the size of the family. ‡ Whatever the man's labour produced less than the provisions of this table required was made up by the parish, whose compliance was subsequently enforced by the Legislature; and the justices were empowered, under certain conditions, to order relief out of the workhouse, and to those who possessed property of their own. 36th Geo. III. c. 23.

Practical Operation of the System.

The practical operation of this system is as follows: Every labourer is presumed to require a gallon loaf of standard wheaten bread, weekly, for every member of his family, and one over: *i. e.* four loaves for three persons; seven for six.—A. B. has a wife and four children; he claims seven gallon loaves, costing, we will suppose, 12s. But his wages are only 9s.: therefore the parish supplies him with 3s. weekly. C. D. has a wife and six children; he requires nine gallon loaves, or 14s. 8d. He earns 10s.; the parish makes up the rest. E. F. is so idle and disorderly, that no one will employ him; but he has a wife and five children, and requires eight gallon loaves for their support. His allowance, then, is 9s. in lieu of the wages which he ought to earn, and 5s. or 6s. to make up the deficiency of these wages.

Many, we doubt not, of the readers of this article will imagine that this is a remarkable or insulated case. So far from it, this sort of machinery has been going on, not only in a single parish, or a single district, but throughout half the country during

* Between 1750 and 1776, the price of wheat had risen from 35s. to 48s. The advance of price would thus account for an increase of about one-third, making the charge for expenditure upon the poor L.920,000; and the population being increased about eighteen *per cent.*, brings an addition of L. 165,600; making L. 1,085,000 as the *natural* increase, instead of the *actual* increase, L. 1,531,000. See *Second Letter to Mr Peel on the Increase of Pauperism*, p. 84.

† Average price of corn for ten years preceding 1775, L. 2, 11s. $3\frac{3}{4}$d.; average from 1775 to 1785 L. 2, 7s. $8\frac{1}{2}$d. The increase of population during that period did not exceed six *per cent.*

‡ For the first introduction of this system, see Sir F. Eden *on the Poor*, Vol. I. p. 579, &c.

the last twenty-five years. It is, in short, universal in the agricultural counties, with such trifling variations as the discretion of some magistrates, or the indiscretion of others, may have locally introduced.

The magistrates with whom this fatal scale originated were actuated, no doubt, by feelings of humanity. The evil against which they had to contend was pressing; the price of provisions was rapidly rising, and the wages of labour bore no proportion to that increase; so that a man's weekly pay was clearly insufficient to support his family. The crisis, too, was formidable; discontent and insubordination existed very widely; and it was naturally thought, that, if real were added to imaginary evils, and hunger sharpened the exacerbation of previous ill temper, the peace of the community might be seriously endangered. The people had been often taught that revolution would make their condition better; and if it became clear that nothing could make it worse, no slight additional force would be given to the arguments of the evil-disposed and discontented. In these difficult circumstances, two modes of administering relief lay before them: one was a compulsory augmentation of the wages of labour to meet the existing case, which they were then empowered to order by a statute 5th Eliz. c. 4, since wisely repealed; the other was the enlargement of parochial aid, in the way we have described. Of two plans, both radically bad, it would be hazardous to decide which might have been followed with less permanent evil to society. Upon the consequences of interfering with the wages of labour, we can only speculate; but the consequences of legalizing this mode of public relief are too plainly written to be concealed. From its publication and general adoption, the industry of the lower classes has deteriorated; their independent feeling has been annihilated; the public burdens have been enormously increased; and the proportion of supply and demand in all the numerous departments of labour has been deranged.

Every new experiment in legislation is interesting to the philosophical inquirer, and valuable to the practical statesman. A system like that which we have been describing, in particular, has placed the inhabitants of a great country in so new and untried a predicament, that it becomes a matter of singular importance to trace its effects, political and moral. The poor, it must be acknowledged, in all crowded and highly civilized states, present a problem of great embarrassment. Where so much wealth and so much penury are seen in opposition; where there is on the one side so much superfluity, on the other so much deficiency; a plan which promises a nearer equalization of the comforts of life brings a strong recommendation, at first sight, to the best feelings of the legislator and the moralist. On this account, our English system of poor-laws has been the subject of frequent eulogy;—has been glanced at with a view to its adoption both with reference to France and Ireland; though the rulers of these countries have hitherto been wisely contented rather to take our warning than to follow our example. Scotland is still in a more hesitating state.

We shall therefore think it necessary, in this place, to point out the consequences of this artificial system, both as they affect the community which affords the relief, and the individuals who receive it. And it will be seen that the general principle which condemns such interference has been strongly confirmed by the practical evils resulting from its infraction.

Political Mischiefs of the Poor-Laws. 1. Disturb the Natural Course of Population.

1. The first, and perhaps the greatest of the political mischiefs occasioned by the poor-laws is this; that they disturb the due proportion between the supply of labourers and the demand for labour. They encourage population, without reference to the funds by which that population is to be supported. They persuade the lower classes to marry as soon as inclination prompts, as if it were needless to reflect whether they can maintain the probable issue of that marriage.

In the natural and healthy course of things, the case of a society increasing too fast can hardly occur in a state of civilization. Some part of the community, indeed, will be pushed to distress and indigence in all countries; but this is not to be set to the account of over-population; it results from the misfortunes to which mankind are subject, and the vicious conduct in which they indulge; and may exist to a considerable extent, where it could not be argued that the country was over-peopled. The natural arrangement is, that a man and his family should depend upon himself; should be supported by his own personal exertions: and knowing this, he considers before he marries whether the ordinary wages of labour in his peculiar vocation will support the probable expenses of the family which he has a right to expect: and if otherwise, he forbears to marry till he can either get better employment, or has laid by some provision to go in aid of his weekly earnings. When labour is so plentiful in the market, that he can only procure employ for half or two-thirds of the year; and when it is so scantily repaid, that though he may earn sufficient to support himself, he can do no more—then he has a clear intimation that he cannot marry without the risk of entailing severe want upon himself and his family. Therefore the labourers, and the demand for labour, keep pace together, by a gentle and equable arrangement, which acts wherever mankind are so far civilized as to know the use of reason, and so prudently governed, as to be allowed to exercise it.

But the law which compels the public to furnish employment to as many as come to claim it, and regulates the wages given in return, not according to the market price of labour, but according to the wants of the labourer, removes at once the natural spring which adjusts the proportion between the demand and the supply of labourers, and exposes the country to all the evils of a redundant population. For as matters are now disposed in England, the question is not whether the parent can support his probable family, but whether the parish will; and the parish pledges itself, by allowed custom, to discharge the parental duty, when it allots a regular addition to the wages of labour in proportion to the number of children. A large family of children is a treasure in America, because such is the demand for labour, that they can in very early life do more than maintain themselves: and they are a treasure in a country

most unlike America, namely, in the agricultural districts of England, because, according to the *lex Julia* which prevails, they place more of the public money at the disposal of the father.

Strange to say, an elaborate defence of the poor-laws has been attempted on this very ground, that they are calculated to accelerate the progress of population at the cheapest rate to the community. Men are not inclined, it is said, to burthen themselves with a family, unless they can promise themselves a reasonable share of comfort. That comfort can only be secured by high wages. But high wages cannot be limited to those who deserve them by their services to the state, in rearing a numerous family: They must be given to single as well as to married men—to those with small families as well as those with large. This would be unpardonably extravagant. Let us therefore sink the price of labour, but secure a support to those meritorious members of society, who furnish the manufactories and the armies with their superfluous children. Let " the law say, " provide the state with children, if you are inclined to marriage; and, should the produce of your industry not be sufficient to rear them in health and vigour, here is a fund that will supply deficiencies; or, if the expense of rearing them prevents your making a provision for old age, here is a fund out of which you shall be supported with decency, whenever your infirmities prevent your power of supplying yourselves. Such a provision must soon counteract any natural impediment to a full supply of people; and if the application of the fund be guarded by wise provisions, securing a man's best exertions while capable, and those provisions are not perverted, the population raised thereby will be of the best sort; it will be robust, healthy, and industrious."*

Danger of such Interference with Population.

An argument so rash and so contradictory to experience as this requires little confutation. A statesman ought to have far more than human sagacity, who takes upon himself to give direct encouragement to population, which he is allowed to do, by the advocates of the poor-laws, " when it shall appear that an increase of people is necessary to the further progress of a nation in wealth and prosperity."† This, surely, is an inquiry too profound and complex to be safely entrusted to any statesman: especially when we remember that encouragements to marriage, like those held out by our laws, cannot be appointed *pro tempore:* the engine, once set in motion, cannot be checked or suspended at pleasure; it is itself artificial, but the provisions for its safe operation must, after all, be those alone which nature has established, whose primary laws were violated in the original speculation. Nature has established an index, in the rate of wages, by which the wants of the society as to population may be clearly ascertained. To set aside this index, and substitute the temporary and short-sighted views of a statesman, as to " the wants, resources, and political relations of a country," is as pernicious in practice as it is unphilosophical in theory. Nature, besides, has provided by an universal principle, that the case supposed to justify this rash and impolitic legislation shall never really exist. It is a point proved beyond the possibility of gainsaying, that population will not only increase up to the limit of available subsistence, but beyond it;—will always reach a certain point of distress. Therefore, this instinctive principle, when left to itself, is always ready to fill up every channel of industry by which a family can be maintained. If, then, the politician ventures to interfere, and accelerate the natural force of this principle, he ought first to ensure the continuance of those circumstances which seem to him to require or justify such acceleration. If this is confessedly beyond his power, he has no right to interfere at all.

These obvious objections against disturbing the natural order of things have met with a most striking confirmation since the peace of 1815. The unnatural acceleration which had taken place during the war became at its conclusion the cause of such severe distress, as almost to render peace a doubtful blessing. Extraordinary circumstances continuing certainly for an unprecedented length of time, had given encouragement to extraordinary exertions; the common observer saw nothing unsound or unhealthy in the state, as long as things remained the same; but the first change of circumstances produced a dangerous revulsion, and proved the evil of empiricism in legislation.

Political Evils of the Poor-Laws. 2. Tendency of Legal Provision to increase Pauperism.

This leads us on to the second mischief arising out of the present state of the poor-laws, which is closely connected with the preceding. They tend to overburthen the land, upon which the funds for their support are charged; and thus to introduce a system of universal pauperism.

Whatever be the nature of the funds destined to support population, the tendency of population is to increase beyond them. This is matter of experience in every department of labour, from the highest to the lowest. In all the branches of national industry, there are always more claimants for employ than can attain it; and, though the excess, for obvious reasons, is at different periods very different in degree, the redundance is always on the side of the labourer;—there are always more workmen than can find employment in manufactures;—always more journeymen mechanics than can be supplied with work;—always more agricultural labourers, than, taking the year throughout, can be employed in useful husbandry. Not even the unhealthy, or degrading, or precarious nature of the employ prevents this effect of the expansive principle of population. Chimney-sweeping, street-sweeping, coal-heaving, mining, thieving, and begging, are all pursued beyond the possibility of maintenance; are all followed by claimants for support beyond the amount of support which they are capable of furnishing.

* *Inquiry into the Policy, Humanity, and past Effects of the Poor-Laws,* page 41. The same argument is supported by the late Mr Rose, in his *Observations on the Poor-Laws.*

† Weyland *on Population and Production,* p. 83.

Poor-Laws.

But this tendency to increase, while it stimulates industry and foresight, occasions little practical disturbance as long as the funds by which such claimants are to be maintained arise from *productive* labour, and are dependent on it. Because the pressure of population, while it requires fresh funds as means of support, contributes to increase those funds by the return which it makes in productive labour.

The case is widely different with respect to eleemosynary funds. Those who claim them are continually becoming more numerous; but the funds themselves, the parish funds, or whatever funds the state can employ, though not exactly defined, are necessarily limited by the ability of the payers. The population, therefore, which is dependent upon these funds, being freed from the restraints which, under usual circumstances, prevent its redundancy, must ultimately surpass any funds that are not equally unlimited, and do not admit of progressive increase in proportion to the progressive demand.

Universal Effect of Public Charities.

The experiment of supporting all who may require eleemosynary maintenance has been too often made to render this conclusion doubtful. Catholic countries, in which the nature of benevolence is every way misunderstood, afford, as might be expected, the most striking proofs that wherever gratuitous supplies are furnished, the demands soon rise above the means of meeting them, or, if the means are unlimited, increase in proportion. Rome, Naples, Cadiz, and indeed all the principal cities of Spain, are described by all travellers as being equally remarkable for indiscriminate bounties, and universal mendicity. The town of Oviedo, for instance, at the time when the late Mr Townsend visited it, afforded a most instructive example. There was an hospicio, or general workhouse, the revenues of which were L. 4000 Sterling; equal probably in Spain to thrice that sum in England; this also served as a foundling hospital; besides which refuge for the poor, and their children, the bishop ordered seventy reals to be distributed at his gates every morning to all comers, and weekly pensions both to widows and orphans. In addition to all this, the canons scattered alms plentifully as they walked through the streets; six convents administered bread and broth at noon, and a commodious hospital was ready to receive the sick and infirm. All these resources were too little, even among so small a population as 7500 souls. "Notwithstanding all that has been done," says that intelligent traveller "(and what more in the way of charity can be devised?) beggars, clothed in rags, and swarming with vermin, abound in every street."

In reading this description, we are struck at once with the folly of such undistinguishing charity. Yet what do we see in the account of Oviedo, but that state on a small scale, which the poor-laws are calculated to render universal in England?—Workhouses in every parish, supported at the public charge, and serving as foundling hospitals, and offering a refuge to the poor and their children. Besides a regular donation to those who may not like the confinement of the workhouse, but can prefer the claim of a burthensome family. And all this independent of the private charity, which we have no wish to see curtailed, but which ought to stand alone; the "bread and broth at noon," judiciously administered, and the public "hospital ready to receive the sick and infirm." The difference in the circumstances and character of the two countries has rendered the consequences hitherto less calamitous in England than in Spain; but the tendency is similar, and the effect equally disproportionate to the means; legal provision has been seen to be no preventive to individual want, or national distress.

And why is this, but because the claimants are daily multiplying in number, and press closer and closer upon the funds destined to satisfy them? The increased and increasing burthen of the rates in England is a sufficient proof of the truth which we desire to establish. Notwithstanding the degradation of dependence,—the liability to vexatious, and often painful removals,—the restraint of workhouses,—and the murmurs of the reluctant dispensers of compulsory alms, to all which an English pauper must submit; experience has made it very evident that, as long as any public support can be relied on, the claimants for it will increase in number and importunity; and that, if any limit is to be set to the demand, it must be sought for somewhere else than in the forbearance of the people, or the decrease of indigence.

Actual Increase of Pauperism.

Already has the claim, in very many instances, exceeded the available resources. In numerous and extensive districts, during the years 1816, 1817, and 1818, it proved impossible for the contributor to furnish the quota which the necessities of those without labour, and, therefore, without support, demanded. Admission into the work and alms-houses, once dreaded as the last resort of hopeless penury, has been courted as a boon, and accepted as a favour. Whilst in London, and other great towns, many almost starving families were deterred from applying to the parish by the crowded, unhealthy, and horrible state of the workhouses into which they would be received, if indeed they could be received at all; many parishes were absolutely unable to raise the assessments, the increase of which, according to the existing laws, has tended only to bring more and more persons upon the parish, and to make what was collected less and less effectual; and yet there was an almost universal cry from one end of the kingdom to the other for voluntary charity to come in aid of the parochial assessments. *

In the mean time, the amount of the rates themselves, which was, in 1785, L. 2,000,000, in 1803, had reached L. 4,267,000, in 1813, L. 6,294,000. † This increase, great in itself, becomes still more important as a proof of the effect of the system, when

* Malthus *on Population*, 5th edition, Vol. II. p. 352.

† *Report of Select Committee*, 1817-1821. The "Letter to Mr Peel" estimates the increase in the price of wheat at 9 *per cent.* in 1803, and the increased population at 17. According to which, the amount ought to have been L. 2,438,670, instead of L. 4,267,965.

we remember that the intervening years had been years of unexampled demand for men and every kind of labour: and also, that, owing to the sudden growth of the burden during the scarcities of 1800 and 1801, a remarkable improvement had taken place in the collection and disbursement of the parochial funds, to so great a degree, that any material diminution cannot generally be expected from more prudent management, whilst the system itself remains. Under these circumstances, if the disorder had not been radical, the annual expenditure ought to have become less and less, instead of increasing, from 1803 to 1813, by a third of the whole, or about a sixth of the proportional amount, after allowing for the increase in population and the price of corn.

It is especially necessary that the price of corn should always be taken into the account. The public is very liable to be misled by an apparent decrease—a decrease in the actual sum, whilst the increase is really proceeding, and the burthen heavier than ever. It is plain, that L. 100, with wheat at 40s. *per* quarter, is equal to L. 200, with wheat at 80s., and is paid with far more difficulty by the agriculturist, who furnishes the great proportion of the rates. If corn continues at the prices of 1822, the rates will not be *effectually* lower, till the L.7,500,000 of 1819 are reduced to L.4,000,000; an event which we no more expect to witness than the reduction of three millions of the population.

The alarming distress which followed the spring of 1815, the consequent increase of the rates, and the difficulty of meeting this demand, led to a long and diligent inquiry into the whole subject before a Committee of the House of Commons, in the session of 1817. From the returns which were then made from the manufacturing towns of Birmingham, Manchester, Coventry, &c.;* and also from many districts solely agricultural, it clearly appeared that the excess of demand above the funds prepared to answer it, was no theoretical or even distant danger, but one which some districts had already experienced, and to which all districts were more or less rapidly approaching. Distraint for rates became very general; and every distraint is an encroachment upon the national resources, and a conversion of capital into income. We soon become alive to the probable result where an individual does this; and if a nation is but an aggregate of individuals, national extravagance and individual extravagance must pay the same penalty, and end in the same fate.

It is impossible to predict, with any certainty, how long or how short a time the present system might go on, before such a crisis arrived. Whenever the charge upon the land for the support of those who do not add enough to the annual produce of the country to support themselves, is so great that the land can be no longer cultivated with a profit, then, of course, it will be thrown up. This charge is gradually increasing every year, if not actually, yet relatively to the price of corn; and the natural effect has already followed in some districts where the pressure is particularly severe. It is evident that, in proportion as this takes place, the rates become still heavier on those who continue to pay. So that the tendency is to contract the contributors annually into a narrower and narrower circle, each step bringing some upon the rates for support who had before assisted to pay them, till the whole cement of society gives way, and the natural gradation of ranks and fortunes, on which its prosperity depends, is sunk and lost in national pauperism.

Such a crisis was clearly apprehended by the Committee of the House of Commons; and with a short extract from their deliberate and valuable *Report*, we shall confirm, as well as conclude, our own reasonings:—

"Whether the assessment be confined to land and houses, as at present, or other denominations of property be made practically liable to the same charge, the Committee feel it their imperious duty to state their opinion, that, unless some efficacious check be interposed, there is every reason to think that the amount of the assessment will continue, as it has done, to increase, till at a period, more or less remote, according to the progress the evil has already made in different places, it shall have absorbed the profits of the property on which the rates may have been assessed: producing thereby the neglect and ruin of the land, and the waste or removal of other property, to the utter subversion of that happy order of society so long upheld in these kingdoms.

"The gradual increase which has taken place both in the number of paupers and in the assessment for their support, can hardly fail to have arisen from causes inherent in the system itself; as it does not appear to have depended entirely upon any temporary or local circumstances. Scarcity of provisions, and a diminished demand for particular manufactures, have occasioned, from time to time, an increased pressure in particular parishes. But by comparing the assessments in the two counties in this kingdom in which the largest portion of the population is employed in agriculture, namely, Bedfordshire and Herefordshire, it will be seen that there has been the same progressive augmentation in the amount of the assessments, as may be observed to have taken place in the manufacturing counties."

	Money Expended on Paupers, in the Year ending Easter 1776, (omitting fractions.)	Average Expenditure on Paupers, 1783, 1784, 1785.	Expenditure, 1803.	Expenditure, 1815.
County of Hereford,	L.10,593	16,727	48,067	59,255
Bedford,	16,662	20,977	38,070	50,370

* In Manchester, the relief given to the *out-door* poor increased within ten years from 1805 to L.14,000, instead of L. 8000 *per annum*; and the whole expenditure, from L. 16,000 to L. 27,000, in the most moderate years—in dear seasons, one-third more. In Birmingham, the increase in ten years was one-third, being L. 20,000 in 1806, L. 30,000 in 1816.—*Commons' Report.*

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The evidence afforded by this table is not to be resisted. The charge on the rates, in 1815, not in two or three counties only, but taking England throughout, was double its amount in 1795; though, in 1815, the price of corn had sunk to a moderate average. What then, except a change in the existing laws and management, is to hinder their doubling again in twenty more years—at least virtually doubling, with respect to the ability of the payers? But it certainly cannot be supposed that land which now, in many cases, pays a rate equal, or more than equal, to the rent, can afford to double that charge, and be cultivated with a profit. In fact, many petitions were laid before Parliament, complaining that the annual value of the property assessed to the poors-rates, was not sufficient to maintain the numerous and increasing claimants, even if it were to be set free of rent; so that the parishes were threatened with a total abandonment of the occupiers of their land. And though these are, indisputably, extreme cases, there is quite enough in the general appearance of the country to warrant the conclusion expressed in the *Report*, and to justify the worst apprehensions respecting the eventual consequence of the system.

This is sufficiently proved by the experience of the five years succeeding 1815, as digested in the following table: *

Years.	Expended for the Relief of the Poor. †	Average Price of Corn *per* Quarter.	
		s.	d.
1815	L.5,418,845	70	6
1816	5,724,506	61	10
1817	6,918,217	87	4
1818	7,890,148	90	7
1819	7,531,650	82	9
1820	7,329,594	69	5

Now, upon the first glance at this table, it will appear, that as the price of corn in 1815 and in 1820 was the same, the amount of the rates ought likewise to have been the same, with the addition of ten *per cent.* for increase of population. It ought, therefore, to have been *six* millions in 1820, according to the scale of 1815. But it is *seven* millions, giving a million, or one-sixth of the whole, as the actual growth of five years. This surely must satisfy every doubt concerning the ruinous tendency of the system, and shows that the only remaining question must be, not whether the evil is in its own nature progressive, but how the progressive evil may be most wisely and effectually restrained.

Such are the political consequences of the system of poor-laws, as now administered in England. Its moral effects are no less pernicious.

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Moral Evils of the Poor-Laws.

1. Improvidence.

1. The first of these which we shall mention is that total improvidence which exists in so remarkable a degree both among the manufacturing and agricultural labourers. In the former class, this is peculiarly inexcusable. The demand for all labour is fluctuating, and liable to occasional and sudden variations. But in manufacturing labour such differences are of most frequent occurrence. A change of fashion at home, or a municipal regulation abroad, the discovery or failure of a mine, the wealth or poverty of a customer, all bear directly upon it, independently of the more important fluctuations arising from the hostile or peaceful relation of neighbouring countries. Therefore labour of this sort, though far more productive in its flourishing seasons, is far more precarious in its eventual success than any other.

The remedy against the inconveniences arising from these causes is to be found in that moral foresight which belongs to intelligent beings, and distinguishes, or ought to distinguish, the civilized and social man from the thoughtless savage. If it is the nature of manufacturing labour to be barren at one season, and productive at another, the superabundance of the harvest must provide against the time of scarcity. But notwithstanding all that must be clearly known, and bitterly experienced on this account, there is among the manufacturing bodies in our large towns a most profligate disregard of any moment beyond the present. The system of the savage is seen in the midst of a crowded population. For a time, on the sudden acquisition of plenty, there is the same waste, the same idleness, the same debauchery, which is quickly succeeded by a similar want, a similar necessity for extraordinary exertion. When the wages of the manufacturer experience a sudden rise, his weekly expenses rise in the same proportion. Perhaps he works but half the week, and spends the rest in low and profligate excess. Perhaps he squanders his superfluous wages in a manner the most absurd, and the most unsuitable to his station in life. But at all events, when the year ends, he is in no sense better than he was at the beginning; his advantages have been altogether thrown away; he is not richer, and in a moral sense he is poorer, because his dissolute habits are more confirmed. It appeared in evidence before the House of Commons, that the ribbon weavers at Coventry, who were at that moment requiring parish relief, had six months before been in the receipt of two or three guineas a week, which they had expended in the most sumptuous manner upon poultry and other luxuries; in selecting which they were so fastidious, that the usual market of the place was not good enough for them, and supplies were regularly sent down from London.

The agricultural labourer has fewer golden opportunities than the manufacturer; still most of them, with frugal habits, might save L. 5 *per annum*, whilst

* *Report on the Poor-Rate Returns*, ordered to be printed 10th July 1821.

† The particular sums expended in law and removals are not specified in the returns after 1815, and therefore cannot be subtracted from the total amount. They amounted in 1813, 1814, 1815, to about L. 330,000 *per annum*.

they are unmarried; whereas not one in fifty, perhaps, is master of that sum at any period of his life. Whenever their wages go beyond their actual necessities, the overplus is carried to the alehouse. If an accident, or an illness, or a failure in the demand for labour, keeps the man from work a fortnight, the parish is called upon to supply the deficiency. That he should have even a week's provision beforehand is entirely out of the question. It would be thought a most unreasonable expectation. Though perhaps he is a single man, and has no family demands; or a man in the flower of his age, who may have earned large wages at task-work for years; or an elderly man whose children are all off his hands. In short, whatever may have been his situation or opportunities, he has always lived, to use a common, but expressive phrase, from hand to mouth.

Now it is impossible to believe that the known and regular provision of the poor-laws is not at the bottom of this unprincipled extravagance, which has now become inveterate throughout the country. We cannot but suppose that in a land where so much intelligence, so strong a moral sense, so active a spirit of industry exists, men who knew that they were liable to accidents and reverses, if they also knew that they had only themselves to depend upon, would employ some part of their present earnings to provide against future contingencies. It may be said that to men who work hard, and are necessarily much collected together, the temptation to low dissipation and extravagance is irresistible. But these temptations are not stronger to one part of the community than the other; and in servants, petty tradesmen, and small farmers, considered as a body, there is much of that forethought and frugality which is the best foundation of individual and national welfare. Many of these, during the unparalleled vicissitudes of the last 25 years, have had more to struggle with than the labourers; yet they have not, in the same regular manner, fallen upon the parish funds, because to these classes such a resource is still considered a reproachful degradation. We argue, that similar frugality would have characterised our labourers also, if their natural disposition to sensuality had not been favoured, rather than restrained, by the assurance of a systematic provision, when vice and imprudence should bring on their necessary results, and terminate in penury.

2. Discontented Spirit arising from Errors as to the Causes of Poverty.

2. Another injurious effect of the poor-laws is the bad and discontented temper which is generated by ignorance of the real causes of poverty. Almost every thing which has hitherto been done for the poor has tended, as if with care and intention, to throw a veil of obscurity over this subject, and to hide from them the real origin of their difficulties. In all cases, the last man whom any one, labouring under misfortune, is *inclined* to accuse, is himself. But the poor-system tends to maintain the opinion, that he is the last person who *ought* to be accused. The workman who can find no employment; the labourer who feels his large and increasing family a burthen which he can ill support; the aged and decrepit, whose pittance barely furnishes them with the necessaries of life; each lay the fault of their particular distress upon the parish, or upon the overseer, or upon the magistrate: but never blame their own imprudence in neglecting a provision, or their extravagance in throwing one away. And when relieved, to the full extent that legal charity can relieve them, they never acknowledge any sense of obligation, unless they should be brought to a better mind by feelings which the poor-laws are rather calculated to extinguish than to awaken.

We can hardly be wrong in setting these errors to the account of the system itself. "On these occasions," as Mr Malthus justly observes, "the only way I have of judging, is to put myself in imagination in the place of the poor man, and consider how I should feel in his situation. If I were told that the rich, by the laws of nature and the laws of the land, were bound to support me, I could not, in the first place, feel much obligation for such support; and, in the next place, if I were given any food of an inferior kind, and could not see the absolute necessity of the change, which would probably be the case, I should think that I had good reason to complain. I should feel that the laws had been violated to my injury, and that I had been unjustly deprived of my right. Under these circumstances, though I might be deterred by the fear of an armed force from committing any overt acts of resistance, yet I should consider myself as perfectly justified in so doing if this fear were removed: and the injury which I believed that I had suffered, might produce the most unfavourable effects on my general dispositions towards the higher classes of society. I cannot, indeed, conceive any thing more irritating to the human feelings, than to experience that degree of distress which, in spite of all our poor-laws and benevolence, is not unfrequently felt in this country; and yet to believe that these sufferings were not brought upon me, either by my own fault, or by the operation of those general laws which, like the tempest, the blight, or the pestilence, are continually falling hard upon particular individuals, while others entirely escape; but were occasioned solely by the avarice and injustice of the higher classes of society.

"On the contrary, if I firmly believed that, by the laws of nature, which are the laws of God, I had no claim *of right* to support, I should, in the first place, feel myself more strongly bound to a life of industry and frugality; but if want, notwithstanding, came upon me, I should consider it in the light of a sickness; as an evil incidental to my present state of being, and which, if I could not avoid, it was my duty to bear with fortitude and resignation. What I received would have the best effect on my feelings towards the higher classes. Even if it were much inferior to what I had been accustomed to, it would still, instead of an injury, be an obligation; and conscious that I had no claim of right, nothing but the dread of absolute famine, which might overcome all other considerations, could palliate the guilt of resistance.

"I cannot help believing, that, if the poor in this country were convinced that they had no claim of *right* to support, and yet in scarcities, and all cases of urgent distress, were liberally relieved, which I think they would be, the bonds which unite the rich with the poor would be drawn much closer than at

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present; and the lower classes of society, as they would have less real reason for irritation and discontent, would be much less subject to such uneasy sensations."

. Extinction of the Genuine Spirit of Charity.

3. To this habitual discontent is to be added the selfishness and mercenary spirit arising from the habit of looking to parochial assistance in every emergency. Instead of that sympathy and active charity which would be shown, we fully believe, in this country at least as much as any other, if the poor were not brought up to expect that relief must be awarded to all in whatever shape it is required, a certain price, an adequate repayment, is demanded, for every trifling service. If an aged parent is lodged under the roof of a child, the parish must give a remuneration. If an orphan is to be provided for, the first question of the relation is, what will the parish allow? If age or occasional illness require some domestic attendance, a demand is regularly made for trouble and loss of time. Dr Chalmers speaks the result of experience both south and north of the Tweed, when he laments it as "a heavy encumbrance on the work of a clergyman, that, in addition to the primary and essential evils of the human constitution, he has to struggle, in his holy warfare, against a system so replete, as pauperism is, with all that can minister to the worst, or that can wither up the best, affections of our species." (*Christian and Civic Economy*, No. 10.)

The effect upon the giver is certainly no better than that upon the receiver of these legal alms; and thus the most valuable part of real charity is thrown away. The immense sums distributed to the poor in this country by the parochial laws are improperly called charity. They want its most distinguishing attribute; and as might be expected from an attempt to force that which loses it essence the moment it ceases to be voluntary, their effects upon those from whom they are collected are as prejudicial as on those to whom they are distributed. On the side of the receivers of this miscalled charity, instead of real relief, we find accumulated distress and more extended poverty; on the side of the givers, instead of pleasurable emotions, unceasing discontent and irritation. How can it be otherwise? The rich, who are little affected by the amount of the rate, pay it as a tax, and either view it in no other light, or apply it as a quietus to their conscience, as if having furnished their legal assessment, they had fulfilled their duty in the way of charity. The middling classes, upon whom the burthen presses most severely,—as the little annuitants, small tradesmen, and inferior farmers,—not only pay it as a tax, but feel it as a tax, and consider that they have the usual privilege of murmuring at its amount. Indeed, the injustice of the system, as it sometimes falls upon payers of this nature, is so glaring, that nothing but the uselessness of remonstrance could prevent its being loudly heard. Those who are constantly supported on parish pay are better off than a large number of those who contribute; they are certain of receiving, as long as there is any capital stock on which a distress can be levied; but the power of paying in the others depends upon their customers, and upon many contingent circumstances. The pauper also is secure in the possession of his effects, those of the contributor are daily liable to be seized.* The pauper, too, can afford to live better, and to spend more on his family or himself throughout the year, than the petty tradesman, or annuitant, or renter of a little land, or many others in that humble but useful class just above the common labourer. These are the persons on whom a scarcity falls heavy; these are the persons who must diminish their consumption; these are the persons who feel the revulsions of trade, and the pressure of taxes; their families must commute bread for potatoes, while their pauper neighbours are living in comparative plenty. Under such circumstances, it is scarcely possible for man not to complain; or to acknowledge the truth of the Christian maxim, "It is more blessed to give than to receive."

4. Encouragement to Immorality.

4. There are other immoral consequences of the poor-laws which are too obvious to need particular illustration. Husbands are encouraged to desert their wives, and fly from the burthen of their families, knowing that they will not be unprovided for. Women are encouraged to admit illicit intercourse, from a confidence that if it should prove fruitful, a marriage will be probably forced from the ordinary operation of the laws; a calculation which begins in vice, and can only end in premature and ill-sorted marriages. Indeed, their general effect on character admits of indisputable proof, independently of all argument or theory. It is notorious that the most steady, industrious, and moral workmen, on whom the employer can place his surest reliance, are those who do not *legally belong* to the parish in which they are living. It would be impossible to desire a more convincing evidence of the pernicious tendency of the present laws. We shall therefore conclude this branch of the subject, by noticing a collateral evil of the system, also tending to demoralize the people. It collects an undue proportion of the population into towns. The population of cities and towns, instead of comprising, as had been calculated during a considerable part of the last, and the whole of the preceding century, about one-third of the na-

* "You do not compel the poor man to sell his furniture before you relieve him?—No—certainly not. But if a man has to contribute to the relief of the poor, and from loss of trade, or from the pressure of children, he is not able to pay his rates, you sell his furniture and effects!—I have been compelled to sign a warrant of distress. Then, is not the pauper that is relieved in a much better condition than the pauper who contributes?—He is so far in a better condition, that what he possesses is more secure to him." *Lords' Report*, p. 25.

By a statute (54th Geo. III. c. 170, s. 11), such persons may now be, by magistrates, legally exonerated from charges.

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tion, now approaches to nearly one-half. From 1801 to 1811, the increase of houses in the towns of Great Britain average 12 *per cent.*, and the inhabitants 15 *per cent.* In the country, the increase of houses somewhat exceeds 11 *per cent.*, and the inhabitants 13 *per cent.* Mr Colquhoun observes, that to whatever cause it may be attributed, there has been a considerable tendency to diminish the rural population, and to increase that of the towns in general.* But the cause is very evident to any one who has watched the operation of the poor-laws. Cottages entail upon the land so heavy a burthen, that no proprietor will suffer one to be erected upon his estate which is not absolutely necessary. He can obtain no rent which can indemnify him for the probable charges of an additional family, which will possess a perpetual claim for support upon his land. But in towns, where the property in land is much subdivided, the immediate advantage of letting small houses at a considerable profit, far overbalances the distant evil arising to the individual from the increase of the rates, to which all the inhabitants of the town will be forced to contribute their share. The consequence is, that there only are houses built, and thither the overflow of the country parishes resort, and going out into the neighbourhood for daily employ, spend their leisure hours in the town, and lose the simple habits as well as the simple recreations of the village.

Plan proposed for Amendment of the System.

Having now explained the poor-system, as it exists at present in England, and shown its injurious effects, both upon the moral and political health of the community, it only remains to advert to the several plans which have been hitherto proposed for its melioration or abolition. And of these, leaving the compulsory contribution to friendly or other provident societies; the assessment of all other property to the rates, as well as that upon which they have been heretofore raised; and the allotment of cottages, with a small quantity of land to the labourers who might have the most numerous families;—as either inadequate, inexpedient, or impracticable remedies—we shall confine ourselves to the two which best deserve the attention of the Legislature, and have obtained the most of it. These are, first, the establishment of a maximum, beyond which the annual amount of the rates in each parish shall not be increased; and next, the gradual abrogation of the law of Elizabeth, on which the whole system has been erected.

1. Plan of establishing a Maximum of the Amount to be raised.

The plan of fixing a maximum has been often recommended, under the alarm arising from the progressive increase of the annual rates. It is proposed to take the average of a certain number of years past, and fix that as the sum which no future assessment should exceed; so that, if the rates of any given parish had amounted, on an average of the largest and smallest sums during the last ten years, to L. 500, L. 500 should be considered as the utmost limit of charitable relief to which the claimants on that parish were legally entitled. A plan of this nature was brought forward in Parliament in the year 1821; but clogged with so many objectionable alterations in the law of settlement, that it met with less attention than the respectability of the mover would otherwise have secured it. There are, however, radical objections to the plan itself. "Under such a law, if the distresses of the poor were to be aggravated tenfold, either by the increase of numbers or the recurrence of a scarcity, the same sum would invariably be appropriated to their relief. If, in the meantime, the statute which gives the poor a right to support, were to remain unexpunged, we shall add to the cruelty of starving them, the injustice of still professing to relieve them. If this statute were expunged or altered, we should virtually deny the right of the poor to support, and only retain the absurdity of saying that they had a right to a certain sum." (Malthus, III. p. 353.)

In order to obviate this evident objection to the measure, a provision was introduced into the bill allowing additions to be made to the fixed maximum, by an extraordinary assembly of the inhabitants and neighbouring magistrates, in very peculiar cases of local pressure or general scarcity. It is plain, however, that this is a virtual abandonment of the principle of the measure; and by necessary consequence, of the measure itself. The right of the people to certain support being recognized, no legislative fiat can limit the extent of that right. No inhabitant could resist the demands of the people; no magistrate could be expected to maintain the maximum, in any season of difficulty, when alone it would be of much practical value. If a dam, which is raised to keep out the encroachments of the water, is to be opened whenever the water presses forcibly against it, the surrounding country has little reason to trust to its effect, when threatened with an inundation.

Plan of a gradually decreasing Maximum.

This objection equally applies to an amendment which has been since proposed, to render the maximum a gradually decreasing maximum, by subtracting from its amount 10s. or 20s. *per cent.* annually, till the whole was extinct. But to any one acquainted with the manner in which the affairs of a parish are and must be conducted, taking the country at large, such impossibilities must occur in the execution of a law of this nature, as render it quite undeserving attention as a national measure. The business of overseer, for the first half of the year, would go on smoothly enough. By that time, three-fourths of the legal assessment would probably be spent. Then all, whatever might be their wants, must be put on short allowance, and future claimants excluded. But each of such claimants would justly consider that he had as good a right to be supported in his hour of need, as those who happened to be visited with misfortune a few months before; and those whose mischance it was to be in distress when the fixed sum was collected and expended, would be particularly ill used on being refused assistance, while so many others around them had enjoyed this advantage. If such a measure were pass-

* Colquhoun *on the Population and Resources of the British Empire*, p. 27.

 ed, it would be virtually repealed in half the parishes of the kingdom before the expiration of five years.

Besides, there is nothing in any measure of this kind, which tends to stem the progress of pauperism; nothing to prevent the numbers from annually increasing, which require public assistance. All the channels by which the main stream is supplied, as described in the beginning of this article, remain the same; why, then, should we expect that the stream itself should grow narrower, or cease to overflow its bounds? If, then, the sum collected were to be divided among all who might be in want, however their number might increase, great misery must ensue; and all the blame of it would be laid, not without much apparent justice, to the charge of the society, which undertook the support of the poor, yet supplied them so sparingly, that they must necessarily die of hunger and disease.

2. Plan for the gradual Abolition of the Poor-Laws.

2. The only measure which can be considered as either politically wise, or practically efficient, is one which shall gradually annihilate the system by attacking directly its vital principle, and striking at the root of the disease. To this end Mr Malthus proposes that a regulation should be made, declaring that no child born from any marriage taking place after the expiration of a year from the date of the law, and no illegitimate child born two years from the same date, shall ever be entitled to parish assistance. And, to give a more general knowledge of this law, and to enforce it more strongly on the minds of the lower classes of people, the clergyman of each parish should, after the publication of banns, read a short address, stating the strong obligation on every man to support his own children; the impropriety, and even immorality, of marrying without a prospect of being able to do this; the evils which had resulted to the poor themselves from the attempt which had been made to assist by public institutions in a duty which ought to be exclusively appropriated to parents, and the absolute necessity which had at length appeared of abandoning all such institutions, on account of their producing effects totally opposite to those which were intended. "This would operate as a fair, distinct, and precise notice, which no man could well mistake; and, without pressing hard upon any particular individuals, would at once throw off the rising generation from that miserable and helpless dependence upon the government and the rich, the moral as well as physical consequences of which are almost incalculable."

Some measure of this kind is not only expedient, but indispensable, if the Committee of the House of Commons are justified in solemnly stating it as their opinion, That unless some efficacious check be interposed, there is every reason to think that the amount of the assessment will continue as it has done to increase, till, at a period more or less remote, it shall have absorbed the profits of the property on which the rate has been assessed, producing thereby the neglect and ruin of the land.

Answer to the usual Objection to this Plan.

The chief practical objection which has been urged against such an enactment is, that it would create two distinct classes, which would exist together in the country for a considerable period of time,—the one class having, and the other not having, a claim to public support; and that this would occasion confusion, discontent, and ultimately turbulence, by which the nation would be kept in continual disorder.

We are of a different mind: and that not only on general grounds, but for reasons of experience. No new measure, in truth, can reduce the lower classes to a more unequal state than the existing system. Every parish has its own rule, founded partly on the ability of the payers, and partly on the character of the overseers. Every district has its own scheme of administration, dependent on the discretion or indiscretion, foresight or carelessness, of the local magistrates. A few parishes, a few bright spots appear, which careful management has preserved from the infection of the surrounding plague; and those parishes are in all respects the best satisfied, because the most comfortable. An account of one of these appears in the evidence before the House, in which the custom of employing labourers by task-work has enabled them to support their families without application to the magistrate; and yet it comes out incidentally that this parish is so great a favourite, that false oaths and other fraudulent means are frequently taken to get into it.

Already, too, there exist in every parish those who have, and those who have not, a claim to support, according as it may happen that they do or do not legally belong to it. What keeps the residents who are non-parishioners from turbulence, or even from complaint? The known law. We argue, that the known law would have the same effect upon those who are born without claim upon any parish. Indeed, the whole country abounds with inequalities of condition among those whose claims are similar; of whom some are, and some are not, effectually relieved by the law on which their claims are founded. Nothing, for instance, can be more different than the degree of assistance awarded to the manufacturing and the rural labourer. In country parishes, the poor do really receive some compensation for their low wages; their children, beyond a certain number, are really supported by the parish; and though it must be a most grating reflection to a labouring man, that he can hardly marry without becoming the father of paupers; yet if he can reconcile himself to this prospect, the compensation, such as it is, is no doubt made to him. But in London, and all the great towns of the kingdom, the evil is suffered without the compensation. The population raised by bounties in the country, naturally and necessarily flows into the town, and as naturally and necessarily tends to lower wages in them; while, in point of fact, those who marry in towns, and have large families, receive no assistance from their parishes, unless they are actually starving: and altogether the assistance which the manufacturing classes obtain for the support of their families, in return for their lowered wages, is perfectly inconsiderable. Whereas the nominal rate of wages is of no more consequence to the labourer who is married and has a family throughout the South of England, than its rate in Hindostan. (See Malthus, II. p. 369.)

It is plain, therefore, that the poor of this country have been used to unequal and very different treatment, and that with much greater appearance of in-

justice than any difference which was founded upon an established law. To say nothing of the advantage which the impudent and daring have long possessed over the humble and unobtrusive character; which imposture has had over honesty, and shameless beggary over honest independence; the circumstance that men who were born in the same class, and labour in the same vocation, and are burthened with the same family, are liable to suffer, and do actually suffer, the widest variations according to the district in which they may happen to reside;—according as the magistrates of that district agree to act; according to the scale of relief they may have adopted; according to the strictness of the inquiry which they are in the habit of making, before they issue an order for relief; in short, according to the views they may take of their own duty and of public expediency. So that we should have no fear of discontent, in any material degree, from the operation of an enactment like that proposed. More especially, as the majority of those whom it concerned finding themselves, according to the natural order of things, so much the more prosperous in consequence of their depending on their own exertions, would be free from the principal temptation to murmur and complain.

It ought to be remembered, farther, that the system now in operation is by no means exempt from the danger of discontented turbulence. Every one is brought up with the belief that the state is bound to provide him with employment and support. When, therefore, the employment assigned him is such as he does not approve, and the recompense awarded him falls below his expectations (and when the employment is a loss to the public, the recompense must often be below even reasonable expectations), he becomes an irritated and uneasy subject; and unless he is restrained by the fear of detection, or by the better influence of moral principles, he vents his spleen by any mischief that is in his power; and the burning of stack-yards, or the destruction of machinery, results from an unsatisfactory interview with the overseer, or an ineffectual appeal to the bench of magistrates. Proofs of this have been already too visible; and vestry meetings, in some counties, have assumed a very seditious appearance: quite enough to prove the evil of accustoming the mass of the population to depend upon any thing except the natural demand for their labour.

The Statute for furnishing Employment may be first repealed.

Should it, however, be considered that more caution and preparation is necessary to pave the way for a total alteration in a system of laws which are unhappily interwoven with the habits of the people; it would be an important step, to begin by repealing that part of the statute of Elizabeth, which empowers the overseers to set the poor to work; that is, in effect, which empowers the labourer to demand work, or money as its substitute. This would confine relief to the impotent and aged, and would take away that part of the law which is most confessedly adverse to all sound principles of policy, and is least capable of any rational defence. There is a satisfaction, no doubt, attendant upon the knowledge, that every individual in the country, if reduced to helpless indigence, has a "local habitation" and a home; that the aged, and the infirm, and the orphan, have a sure provision.* And though man may, no doubt, become improvident, and parents may sometimes be induced to abandon their children, from a conviction, that they will not be allowed to starve, yet if relief had never been extended beyond these objects, the evil would not have become practically burthensome as it is now experienced to be.

No Able-bodied Labourer to be relieved.

If then it should be determined, for the present at least, to retain this part of the system, let a wiser course be commenced, by laying aside the attempt to "set the poor on work;" and let it be declared that from such a time, no able-bodied man shall have any claim to employment or relief from the parish for himself or his family. Such a measure has the advantage of being strongly recommended by the *Report* of the Committee, to which we have so often alluded. Indeed, a decided opinion is there given, that, even as the law now stands, "an order for relief is invalid, which does not adjudge the party to be 'impotent,' as well as 'poor.'" And a mode is suggested in which this alteration of the prevailing system might be effected humanely and gradually. It is submitted to the consideration of the House, whether, when the demand for labour may have revived, it may not be safely provided, that from and after a certain time, no relief shall be extended to any child whose father, being living, is under years of age; a principle which, by altering the age from time to time, might, if it should be thought desirable, be carried still further into operation. It may also be provided, with a similar view, that from and after a specific time, no relief shall be provided for any child whose father, being living, has not above children, under years of age. The *Report* proceeds to suggest that it may be hereafter enacted, that no person should be provided with work by the parish other than those who are already so provided, and who might be permitted to continue till they could provide for themselves; but if the change made by this provision might be thought too rapid, limitations might still be introduced, the effect of which would render it more gradual: as, by enacting that none shall be provided with employment who are between the ages of 18 and 30, and then, after a certain

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* This feeling has induced the author of the Letter to Mr Peel, who well deserves attention, to make the following reflection:—"Let me thus dismiss the present branch of the argument, with the hope that indigence, arising either from infirmity, age, infancy, great number of children, and even accidental failure of employment, may possibly be relieved by law—not fully and adequately to our feelings—yet permanently and systematically, without necessarily extending the evil."

Such a concession, from one so well aware of the moral evils of the poor-laws, shows the embarrassments with which the subject is involved.

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lapse of time, that none between 16 and 35, 40, and so on, till the object shall be gradually effected.

We entertain no sort of doubt that a law of this kind would, in a very short time, benefit the labourers themselves. What, indeed, can be more depressing or injurious to them, than the system which is common in some districts, according to which labourers, under the denomination of *roundsmen*, are sent from farm to farm, and paid at the lowest possible rate, and that rate not depending upon their skill or industry, but upon the largeness of their families? and not by the person for whom they labour, but, in a great part, out of the parish funds? Both the Committees reprobate this practice in pointed terms, but the Lords do not seem to have observed that it grows naturally out of the system of our poor-laws; and if that "system is essentially maintained," every labourer in the kingdom must in the end be treated as a roundsman. The poor-laws encourage the increase of the number of workmen beyond the demand for their labour: the poor-laws then oblige the parish to employ these supernumeraries at its own expense. But none of the employers of labour are in want of these hands, otherwise they would not be left to seek for work: still they must be supported: what alternative is there, except either to maintain them in idleness, or to parcel them out in the district which contributes to the rate? Certainly it is a plan which reduces the free labourer to the condition of a slave; but let the blame fall where it is due, upon the law itself; or let it be shown how some such scheme can be avoided, unless the men are to be unemployed altogether.

With such a Provision, the Plan of a Maximum might be advantageously united.

In conjunction with some enactment denying the claim of the able-bodied labourer to legal relief in any shape, and so tending to undermine the whole system—a limitation of the assessment to be annually raised might be useful, because it would be a sort of acknowledgment of the indisputable truth, that the Legislature had hitherto taken more upon itself than it was able to accomplish, and that the funds for the relief of the distressed, as well as for the employment of labour, really are limited, though the practice of the country supposes them inexhaustible; and that, in point of fact, they have already reached the bounds beyond which it is either not possible or not safe to proceed. This would gradually open the eyes of the poor to a truth which cannot be long concealed, and induce them to depend upon themselves. It would also furnish an argument to those who attempt to restore, or rather to create, in the poor a feeling of reliance on their own industry. As matters stand at present, all recommendations of Saving Banks, all enforcements of the necessity of foresight, are cut short by reference to the parish. You may be out of work; the parish must find it for me. You may be overburdened with a young family; the parish must allow accordingly. You may grow infirm or old; I can but come to the parish. But if a positive limit were set to the parochial assessment, what is theoretically absurd, might be practically useful; because there would be opportunity of rejoinder to these conclusive reasonings, from the inadequacy of the parish allowances; and a whole meal from former savings might appear better than the half loaf which public charity would procure. But, in the mean time, the encouragement of frugal habits is proved to be a visionary hope among the lower classes of the community; and the declaration of the Lords' Committee, however undeniable, will remain a dead letter as to practical effect: "Parochial relief, under the best and most considerate administration of it, can never be so satisfactory to the person who is the object of it, or so consistent with those honourable feelings of pride and independence which are implanted in the heart of man, as that resource which is the result of his own industry and the produce of his own exertions." This is unintelligible language, to those at least who have been born in the south of England within the last forty years. Parish relief, instead of being dreaded as a disgrace, or looked to as a last resource, is, in truth, the first consideration. To become domiciliated in a *good parish* is the grand object, and leads to numberless cheats and perjuries; the next concern is to obtain as much as possible from it; which the single men effect by threatening to bring a wife and family upon the parish funds, if they are not relieved to their satisfaction; and the married men by actually doing so. A system which encourages these feelings and habits has been called a humane, a wise, an economical system; and justly, if it is humanity to support profligacy at the expense of the industrious; if it is wise to diffuse habits of improvidence, vice, and dishonesty throughout the land; if it is economical to sink capital in order to furnish income to the extravagant.

Answer to the Objection, from Variations in the Price of Corn.

The most plausible objection to this plan of commencing an improvement in the principle of the poor-laws, by confining relief to the *impotent* poor, arises from the variations in the price of corn; a recurrence of which it seems right to anticipate in the present state of our agriculture and population. There have been many years since 1795 in which the market rate of wages would not generally support a family: neither is it in the nature of things that the wages of labour should rise with the price of corn, when that increase of price is occasioned by a deficiency in the supply. To raise them arbitrarily, as some persons have ventured to recommend, would only be to relieve one evil in the body politic by the introduction of another; and, though no remedy could easily be worse than the present disease, it is wiser, at all events, to "bear the ills we have, than fly to others which we know not of."

In reply, however, to this objection, it may be remarked, that the natural price of labour will be more nearly approached by the market price, in proportion as parochial payments are done away; and the employer will still be a gainer, because his assessment will be diminished in the same proportion: while population and production, keeping more even pace together, when relieved from the disturbing influences which prevail at present, the prices of corn will be subject to less variation. In the case, however, of any unusual disparity between the price of labour and the price of provisions, such as occurred in the years 1795 and 1800, or of any temporary or local pressure, from a difficulty in procuring employment, such as must always be expected

in some districts of a great manufacturing county, and which was almost universal in the years immediately succeeding the peace;—the principal inhabitants ought to agree together on the most practicable mode of assisting the largest families, and enabling their poorer neighbours to weather the exigencies of the season.* The political objections which exist against indiscriminate relief do not affect extraordinary cases. That which would be most pernicious as daily diet, when applied as medicine, restores health to the constitution. Neither are we so forgetful of the duties enjoined upon us as Christians as to exclude charity from our domestic economy: our object is not to annihilate charity, but to render it profitable both to the giver and receiver. This is truly the case when our assistance, of whatever sort, is bestowed upon a known object, and for a definite purpose, instead of being thrown into a common fund, for which all scramble, and from which those who scramble most shamelessly get the largest share. The known claim to parochial aid, and the actual pressure of the funds which it demands, are an impediment, in the present state of the law, to private benevolence; together with a general conviction, that what is called, though falsely called, *the charity of the country*, has increased the distress which it professes to relieve.

And to say the truth, when we consider the degree of labour, and attention, and intelligence employed upon the concerns of the poor in late years, we may justly affirm, that, if it had been possible for things to go on well upon a wrong system, and to succeed on an erroneous principle, they must have succeeded, and the condition of the poor in England must have been most prosperous; and that it has not been so, with all these advantages, is in itself a sufficient evidence that the principle is radically unsound.

Scotch Poor-Laws.

It will be observed, that our remarks in the preceding article apply principally to England, as the native country of the poor-laws, and to those few districts of Scotland where the practice has been assimilated to that of England. An abstract of the laws which relate to the assistance and management of the poor in Scotland will be found in the *Encyclopædia.* We must add, however, that, since that publication, a very important case has been determined by the Court of Session, which turned upon this question; viz. Whether, under the Scotch poor-laws, those persons are entitled to relief who, without any personal infirmity, are rendered unable, by the high price of provisions, to maintain themselves in time of dearth? And whether an assessment for the relief of such persons was legal? The Court decreed, on the 17th of January 1804, that such relief and assessment were legal under the statutes; and the arguments used to obtain a contrary decree were, *not that the statutes were not in force,* but that they did not strictly include this particular case. It came from the parish of Dunse in Berwickshire.

The Court of Session has also repeatedly decided that "a pauper has a title to the charity of any parish in which he has resided three years, supporting himself during that period by his own industry."

In consequence, many parishes have had recourse to legal assessments. "In small country parishes, or in parishes where there are no considerable towns or villages, the assessments are levied according to the valued rent of the lands, the one-half being paid by the heritors, and the other half by the tenants. But in large parishes, the assessments are made according to the real annual rents of lands and houses, a fourth part being deducted to the proprietors of houses for reparations; the half of the assessment is paid by the proprietors or landlords, and the other half by the tenants or possessors. The assessments are made annually by a joint meeting of the heritors and kirk-session of the parish, held, by act of Parliament, on first Tuesday of August or first Tuesday of July, who appoint a collector, who makes a new rental each year of lands and houses.†

The parishes in which such assessments have been enforced present a striking contrast to those which are managed upon the more primitive and economical system. The demands upon the legal funds have increased at least tenfold, and thus furnish a remarkable confirmation of the arguments by which the English poor-laws are impugned; against the further admission of which into this comparatively prudent and well regulated country, all its wisest and most benevolent members are lifting up their voice of warning and exhortation.‡

Dr Chalmers, in particular, in addition to all his other important obligations, has recently conferred a new benefit upon the public, by practically showing that even the unpromising population of Glasgow may be satisfactorily provided for through the old channel of voluntary contributions, without recourse to compulsory funds. We would gladly refer any readers of the foregoing article who may entertain a prejudice against its tendency, to the Speech delivered by that gentleman before the General Assembly of the Church of Scotland in May 1822, and especially to the practical details related in the Appendix to it. (N. N. N.)

* In this way of occasional contribution, great local distress in Ireland has been effectually relieved during the summer of 1822. But what miserable politicians would those prove, who, on account of a temporary evil in a country so every way anomalous as Ireland, would venture to introduce, and apply to the Irish character, a permanent system of parochial legislation?

† See *Notes on the Scotch Poor-Laws*, by the Reverend Sir Henry Moncreiff Wellwood, and the late Mr Horner, appended to Mr Whitbread's *Speech on the Poor-Laws*, 1807.

‡ *Report of the Committee of the General Assembly*, 1817, appended to the *Report of the House of Commons.*

POPULATION.

Population.

Object of the Article.

The population of the principal states, of which an account has been given in the course of this work, will be found under their proper heads. The object of this article is to explain the general laws which regulate the increase or decrease of population, and the manner in which they affect the state and condition of human society.

Natural and Necessary Tendency of all Plants and Animals to Increase in a Geometrical Progression.

In taking a view of animated nature, we cannot fail to be struck with a prodigious power of increase in plants and animals. Their capacity in this respect is, indeed, almost infinitely various, according with the endless variety of the works of nature, and the different purposes which they seem appointed to fulfil. But whether they increase slowly or rapidly, if they increase by seed or generation, their natural tendency must be to increase in a geometrical ratio, that is, by multiplication; and at whatever rate they are increasing during any one period, if no further obstacles be opposed to them, they must proceed in a geometrical progression.

In the growth of wheat, a vast quantity of seed is unavoidably lost. When it is dibbled instead of being sown in the common way, two pecks of seed wheat will yield as large a crop as two bushels, and thus quadruple the proportion of the return to the quantity of seed put into the ground. In the *Philosophical Transactions* for 1768, an account is given of an experiment in which, by separating the roots obtained from a single grain of wheat, and transplanting them in a favourable soil, a return was obtained of above 500,000 grains. But, without referring to peculiar instances, or peculiar modes of cultivation, it is known that calculations have often been made, founded on positive experience of the produce of wheat in different soils and countries, cultivated in an ordinary way, and making allowance for all ordinary destruction of seed.

Humboldt has collected some estimates of this kind, from which it appears that France, the north of Germany, Poland, and Sweden, taken generally, produce from five to six grains for one; some fertile lands in France produce fifteen for one; and the good lands in Picardy and the Isle of France from eight to ten grains for one. Hungary, Croatia, and Sclavonia, yield from eight to ten grains for one. In the Regno de la Plata, twelve grains for one are produced: near the city of Buenos Ayres, sixteen for one: in the northern part of Mexico seventeen; and in the equinoctial regions of Mexico twenty-four for one. (*Nouvelle Espagne*, L. IV. C. ix. p. 98.)

Now, supposing that in any one country during a certain period, and under the ordinary cultivation, the return of wheat was six grains for one, it would be strictly correct to say, that wheat had the capacity of increasing in a geometrical ratio, of such a nature as to sextuple itself every year. And it might safely be calculated hypothetically, that if, setting out from the produce of one acre, land of the same quality could be prepared with sufficient rapidity, and no wheat were consumed, the rate of increase would be such as completely to cover the whole earthy surface of our globe in fourteen years.

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In the same manner, if it be found by experience that on land of a certain quality, and making allowance for the ordinary mortality and accidents, sheep will increase on an average, so as to double their numbers every two years, it would be strictly correct to say, that sheep have the natural capacity of increasing in a geometrical progression, of which the common multiple is two, and the term two years; and it might safely be said, that if land of the same quality could be provided with sufficient rapidity, and no sheep were consumed, the rate of increase would be such, that if we were to begin with the full number which could be supported on an acre of land, the whole earthy part of the globe might be completely covered with sheep in less than 76 years.

If out of this prodigious increase of food, the full support of mankind were deducted, supposing them to increase as fast as they have ever yet increased in any country, the deduction would be comparatively inconsiderable; and the rate of increase would still be enormous, till it was checked, either by the natural want of will on the part of mankind to make efforts for the increase of food, beyond what they could possibly consume, or after a certain period, by their absolute want of power to prepare land of the same quality, so as to allow of the same rate of progress.

Owing to these two causes combined, we see that, notwithstanding this prodigious *power* of increase in vegetables and animals, their actual increase is extremely slow; and it is obvious, that, owing to the latter cause alone, and long before a final stop was put to all further progress, their actual rate of increase must of necessity be very greatly retarded; as it would be impossible for the most enlightened human efforts to make all the soil of the earth equal in fertility to the average quality of land now in use; while the practicable approaches towards it would require so much time as to occasion, at a very early period, a constant and great check upon what their increase would be, if they could exert their natural powers.

Elevated as man is above all other animals by his intellectual faculties, it is not to be supposed that

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the physical laws to which he is subjected should be essentially different from those which are observed to prevail in other parts of animated nature. He may increase slower than most other animals; but food is equally necessary to his support; and if his natural capacity of increase be greater than can be permanently supplied with food from a limited territory, his increase must be constantly retarded by the difficulty of procuring the means of subsistence.

The Power which Man possesses of Producing his own Food, is strictly limited by the Quantity and Nature of the Soil which he can command.

The main peculiarity which distinguishes man from other animals, in the means of his support, is the power which he possesses of very greatly increasing these means. But this power is obviously limited by the scarcity of land, by the great natural barrenness of a very large part of the surface of the earth, and by the decreasing proportion of produce which must necessarily be obtained from the continual additions of labour and capital applied to land already in cultivation.

It is, however, specifically with this diminishing and limited power of increasing the produce of the soil, that we must compare the natural power of mankind to increase, in order to ascertain whether, in the progress to the full cultivation and peopling of the globe, the natural power of mankind to increase must not, of absolute necessity, be constantly retarded by the difficulty of procuring the means of subsistence, and if so, what are likely to be the effects of such a state of things.

Mode of determining the natural Rate of Increase which applies to Mankind.

In an endeavour to determine the natural power of mankind to increase, as well as their power of increasing the produce of the soil, we can have no other guide than past experience.

The great check to the increase of plants and animals, we know from experience, is the want of room and nourishment; and this experience would direct us to look for the greatest actual increase of them in those situations where room and nourishment were the most abundant.

On the same principle, we should expect to find the greatest actual increase of population in those situations where, from the abundance of good land, and the manner in which its produce is distributed, the largest portion of the necessaries of life is actually awarded to the mass of the society.

Of the countries with which we are acquainted, the United States of America, formerly the North American Colonies of Great Britain, answer most nearly to this description. In the United States not only is there an abundance of good land, but from the manner in which it has been distributed, and the market which has been opened for its produce, there has been a greater and more constant demand for labour, and a larger portion of necessaries has been awarded to the labourer than in any of those other countries which possess an equal or greater abundance of land and fertility of soil.

Here, then, we should expect to find that the natural power of mankind to increase, whatever it may be, would be most distinctly marked; and here, in consequence, it appears that the actual rate of the increase of population has been more rapid than in any known country, although, independently of the abundance of good land, and the great demand for labour, it is distinguished by no other circumstances which appear to be peculiarly favourable to the increase of numbers.

It has been stated that all animals, according to the known laws by which they are produced, must have a capacity of increasing in a geometrical progression. And the question with regard to man is, what is the rate of this geometrical progression?

Fortunately in the country to which we should naturally turn our eyes for an exemplification of the most rapid rate of increase, there have been four enumerations of the people, each at the distance of ten years; and though the estimates of the increase of population in the North American Colonies at earlier periods were of sufficient authority, in the absence of more certain documents, to warrant most important inferences, yet as we now possess such documents, and as the period they involve is of sufficient length to establish the point in question, it is no longer necessary to refer to earlier times.

Increase of Population in the United States of America.

According to a regular census made by order of Congress in 1790, which there is every reason to think is essentially correct, the white population of the United States was found to be 3,164,148. By a similar census in 1800, it was found to have increased to 4,312,841. It had increased then during the ten years from 1790 to 1800, at a rate equal to 36.3 *per cent.*, a rate which, if continued, would double the population in twenty-two years and about four months and a half.

According to a third census in 1810, the white population was found to be 5,862,092,* which, compared with the population of 1800, gives an increase in the second ten years at the rate of nearly 36 *per cent.*, which, if continued, would double the population in about twenty-two years and a half.

According to the fourth census in 1820, the white population was found to be 7,861,710,† which, compared with the population of 1810, gives an increase in the third ten years at a rate *per cent.* of 34.1, which, if continued, would double the population in twenty-three years and seven months.

If we compare the period of doubling according to the rate of increase in the most unfavourable ten years of this series, with twenty-five years, we shall find the difference such as fully to cover all the increase of population which would have taken place from emigration.

Amount of Emigration.

It appears from a reference to the most authentic documents which can be collected on both sides of the Atlantic, that the emigration to the United States, during the last twenty-five years, falls decidedly short

* These numbers are taken from Dr Seybert's *Statistical Annals*, p. 23.

† This number is taken from the *American National Calendar* for 1822, and has since been compared with the original census as published for the use of the members of Congress.

Population. of an average of 10,000 a-year. Dr Seybert, the best authority on the other side of the water, states that, from 1790 to 1810, it could not have been so much as 6000 a-year. Our official accounts of the number of emigrants to the United States from England, Ireland, and Scotland, during the ten years from 1812 to 1821, inclusive, give an average of less than 7000, although the period includes the extraordinary years 1817 and 1818, in which the emigrations to the United States were much greater than they were ever known to be before or since. The official American accounts, as far as they go, which is only for two years from the 30th September 1819, tend to confirm this average,* and allowing fully for the emigrants from other European countries, the general average will still be under the ten thousand.

A new mode has, however, lately been † suggested of estimating the amount of increase in any country derived from emigration. It has been justly stated, that when a census is taken every ten years, and the population is distinguished into those above, and those below ten years of age, all above ten years of age, exclusive of emigrants, must have existed in the census immediately preceding, and, consequently, after having made a proper allowance for the mortality during these ten years, the excess above the remaining number must be attributed to emigration. If we had the means of estimating with accuracy the loss which would be sustained in America in ten years by a population not increased by additional births, this mode of estimating the amount of emigration would be unobjectionable, and often very useful.

But, unfortunately, the means are deficient. Even the annual mortality in the United States is not known. It was supposed by Dr Price (Vol. II. p. 50, 7th edit.) to be 1 in 50; by Mr Barton, in the *Transactions of the Society* at Philadelphia (Vol. III. No. 7), 1 in 45; and it is stated by Mr Bristed, in his work on *America and her Resources* (p. 20), that the annual deaths average throughout the United States 1 in 40, in the healthiest districts 1 in 56, and in the most unhealthy 1 in 35.

If, however, we could ascertain accurately the average annual mortality, we should still be unable to ascertain the amount of the loss in question; as, under any given law of mortality, it would depend so very much upon the rate at which the population was increasing. The truth of this observation will be placed in a striking light by the following short table, with which we have been favoured by a very able calculator, Mr Milne, author of a well-known *Treatise on Annuities and Assurances.* It is constructed on the supposition that the population, in each case, is always subject to the same law of mortality as that which prevailed in all Sweden and Finland during the five years, ended with 1805, and that the number of births in the present year living in each case is 10,000.

	The Population constantly the same.	The Population increasing and having increased in geometrical progression for more than 100 years so as to double itself every 50 years,	25 years,
Total population ten years since, - -	393,848	230,005	144,358
Total above 10 years of age now, - -	320,495	195,566	126,176
Died during the term of 10 years, out of those living at its commencement,	73,353	34,439	18,182
Being one of -	5.3692	6.6786	7.9396

We see from this table, that, under the same law of mortality, the difference of loss sustained in ten years, by a people not increased by fresh births, would in the three cases supposed of a stationary population, a population doubling in 50 years, and a population doubling in 25 years, be as 1 in 5.3692, 1 in 6.6786, and 1 in 7.9396; and that when the population is doubling itself in 25 years, the loss would be very little more than one-eighth.

But the censuses must be allowed to form a *prima facie* evidence, that the population of the United States has, for a considerable time, been going on doubling itself in 25 years; and assuming this evidence to be true, which we are warranted in doing till better evidence is produced on the other side, it will appear that the amount of immigration, deduced from the rule here referred to, is less than 10,000 a-year.

Thus the white population of the United States in 1800 was 4,312,841. ‡ This population, without further accession of births, would in 1810 be diminished one-eighth, or reduced to 3,773,736. In 1810 the population above ten years of age was 3,845,389; and subtracting the former number from the latter, the difference, or amount of emigration, will be 71,653, or 7165 a-year.

Again, the white population of 1810 was 5,862,092, which, diminished by one-eighth in ten years, would be 5,129,331. The population above ten years of age in 1820 was 5,235,940. § Subtracting the former from the latter, the difference, or amount of emi-

* *American National Calendar* for 1821, p. 237, and *North American Review* for October 1822, p. 304.
† This mode was suggested by Mr Booth in Mr Godwin's *Answer* to Mr Malthus.
‡ Seybert's *Statistical Annals*, p. 23.
§ *American National Calendar* for 1822, p. 246.

gration, is 106,608, or 10,660 a-year; showing, as we should expect, a greater amount of emigration from 1810 to 1820 than from 1800 to 1810, but even in the latter ten years, and including emigrations from Canada, as well as all other countries, little exceeding 10,000.

Altogether then we can hardly err in defect, if we allow 10,000 a year for the average increase from emigration during the 25 years from 1795 to 1820, and applying this number to the slowest period of increase, when the rate was such as to double the population in 23 years and 7 months; it may be easily calculated, that in the additional year and five months, a population of 5,862,000 would have increased to an amount much more than sufficient to cover an annual emigration of 10,000 persons, with the increase from them at the same rate.

Such an increase from them, however, would not take place. It appears from an account in the *National Calendar* of the United States for the year 1821, that of the 7001 persons who had arrived in America from the 30th of September 1819 to the 30th of September 1820, 1959 only were females, and the rest, 5042, were males,*—a proportion, which, if it approaches towards representing the average, must very greatly reduce the number from which any increase ought to be calculated.

If, however, we omit these considerations; if we suppose a yearly emigration from Europe to America of 10,000 persons for the 25 years, from 1795 to 1820, the greatest part of which time Europe was involved in a most extensive scene of warfare requiring all its population; and further, if we allow for an increase of all the emigrants during the *whole period*, at the fullest rate, the remaining numbers will still be sufficient to show a doubling of the population in less than 25 years.

The white population of 1790 was 3,164,148. This population, according to the rate at which it was increasing, would have amounted to about 3,694,100 in 1795; and supposing it to have just doubled itself in the 25 years, from 1795 to 1820, the population in 1820 would have been 7,388,200. But the actual white population of 1820 appears, by the late census, to be 7,861,710, showing an excess of 473,510, whereas an emigration of 10,000 persons annually, with the increase from them at 3 *per cent.*, a rate which would double a population in less than 24 years, would only amount to 364,592.

But the most striking confirmation of the censuses of the United States, and the most remarkable proof of the rate of increase being occasioned almost exclusively by procreation, have been furnished to us by Mr Milne. In his work on *Annuities and Assurances*, which contains much valuable and interesting information on the subject of population, he had noticed the effects of the frequent pressure of want on the labouring classes of Sweden; which, by increasing the proportion of deaths, rendered the law of mortality so accurately observed in that country by Professors Wargentin and Nicander, inapplicable to other countries more favourably circumstanced. But the law of mortality was observed to be gradually improving from the time that Dr Price constructed his Swedish table; and the period from 1800 to the end of 1805 was so free from scarcities and epidemics, and the healthiness of the country had been further so much improved by the introduction of vaccination, that he justly thought the law of mortality, as observed during these five years, might suit countries where the condition of the people was known to be much better than it had generally been in Sweden. On these grounds he applied the Swedish law of mortality, during the term mentioned, to the hypothesis of a population which had been increasing by procreation, in geometrical progression, for more than a hundred years, so as to double every twenty-five years. Assuming this population to be one million, he distributed it, by a process well known to persons conversant with these subjects, into the different ages referred to in the American censuses, and then compared them with the same number of persons distributed according to the actual returns of the ages in the American censuses for the three periods of 1800, 1810, and 1820.

The results are as follows:

Distribution of a Population of 1,000,000 *Persons in the under mentioned intervals of Age.*

Between the Ages of	According to The Hypothesis.	United States. Census of 1800.	Census of 1810.	Census of 1820.
0 & 10	337,592	334,556	344,024	333,995
10 & 16	145,583	154,898	156,345	154,913
16 & 26	186,222	185,046	189,227	198,114
26 & 45	213,013	205,289	190,461	191,139
45 & 100	117,590	120,211	119,943	121,839
0 & 100	1,000,000	1,000,000	1,000,000	1,000,000
Under 16	483,175	489,454	500,369	488,908
Above 16	516,825	510,546	499,631	511,092

The general resemblance in the distribution of the ages in the three different censuses to each other, and to the hypothesis, clearly proves,

1*st*, That the distribution of the ages in the different enumerations must be made with some care, and may, therefore, be relied on as in the main correct.

2*dly*, That the law of mortality assumed in the hypothesis, cannot deviate essentially from the law of mortality which prevails in the United States; and,

* The details for the next year have not yet been printed, but it is known that the whole number of passengers arriving in the United States was 10,722, of which 2415 were from the United States, leaving 8307 foreigners. *American Review* for October 1822, p. 304.

Population.

3dly, That the actual structure of the American population differs very little from what it would be if it were increasing regularly from procreation only, in geometrical progression, so as to double itself every 25 years; and that we may, therefore, safely infer that it has been very little disturbed by immigration.

If to these proofs of the rapid increase of population which has actually taken place, we add the consideration that this rate of increase is an average applying to a most extensive territory, some parts of which are known to be unhealthy; that some of the towns of the United States are now large; that many of the inhabitants must be engaged in unwholesome occupations, and exposed to many of those checks to increase which prevail in other countries; and further, that in the western territories, where these checks do not occur, the rate of increase is beyond comparison more rapid than the general average, after making the fullest allowance for immigration, it must appear certain, that the rate at which the population of the whole of the United States has actually increased for the last 30 years, must fall very decidedly short of the actual capacity of mankind to increase under the most favourable circumstances.

The Rate of Increase in the United States confirmed by the Increase of other Countries.

The best proof that can be obtained of the capacity of mankind to increase at a certain rate, is their having really increased at that rate. At the same time, if any peculiarly rapid increase which had appeared to take place in a particular country, were quite unsupported by other evidence, we might be disposed to attribute it to error or accident, and might scarcely be justified in founding important conclusions upon it. But this is far from being the case in the present instance. The rate of increase which has at times taken place in other countries, under the operation of great and obvious checks to the progress of population, sufficiently shows what might be expected if these checks were removed.

Increase of Population in New Spain.

The countries most resembling the United States of America are those territories of the New World which lately belonged to Spain. In abundance and fertility of soil they are indeed superior; but almost all the vices in the government of the mother country were introduced into her colonial possessions, and particularly that very unequal distribution of landed property which takes place under the feudal system. These evils, and the circumstance of a very large part of the population being Indians in a depressed state, and inferior in industry and energy to Europeans, necessarily prevent that rapid increase of numbers which the abundance and fertility of the land would admit of. But it appears from the instructive and interesting account of New Spain, which M. Humboldt has not long since given to the public, that for the last half of the eighteenth century, the excess of the births above the deaths, and the progress of the population, have been very great. The following are the proportions of burials to baptisms in the registers of eleven villages, the details of which were communicated to M. Humboldt by the curates:

	Burials.	Baptisms.
At Dolores,	100	253
Singuilucan,	100	234
Calymaya,	100	202
Guanaxuato,	100	201
St Anne,	100	195
Marsil,	100	194
Queretaro,	100	188
Axapuzco,	100	157
Yguala,	100	140
Malacatepec,	100	130
Panuco,	100	123

The mean proportion is 100 to 183.

But the proportion which M. Humboldt considers as best suited to the whole of the population is 100 to 170.

In some of the villages above mentioned, the proportion of the births to the population is extraordinarily great, and the proportion of deaths very considerable, showing, in a striking point of view, the early marriages and early deaths of a tropical climate, and the more rapid passing away of each generation. *

At Queretaro, it appears that the baptisms were to the population as 1 to 14, and the burials as 1 to 26.

At Guanaxuato, including the neighbouring mines of St Anne and of Marsil, the baptisms were to the population as 1 to 15, and the burials as 1 to 29.

The general result from all the information which could be collected was, that the proportion of births to the population, for the whole of the kingdom of New Spain, was as 1 to 17, and of the deaths as 1 to 30. These proportions of births to deaths, if they were continued, would double the population in $27\frac{1}{2}$ years.

M. Humboldt further observes, that the information which he had collected respecting the proportions of the births to the deaths, and of these to the whole population, proves, that if the order of nature were not interrupted by some extraordinary and disturbing causes, the population of New Spain ought to double itself every nineteen years. †

It is known, however, that these causes do occur in the actual state of things: consequently we cannot consider the actual rate of the increase of population in New Spain as greater than according to the former calculation. But a rate of increase such

* The details which M. Humboldt has given of the population of New Spain are highly interesting, as they are the first of any consequence which the public has yet received of a tropical climate. The peculiarities which mark them are exactly of the kind which might have been expected, though the proportion of births is still greater than we could have ventured to suppose.

† *Essai Politique sur le Royaume de la Nouvelle Espagne*, Liv. II. Chap. iv. pp. 330, *et seq.* Vol. I. Oct.

as to double the population in $27\frac{1}{2}$, in spite of all the obstacles enumerated by M. Humboldt, is very extraordinary. It is next to the increase of the United States, and greatly superior to any that can be found in Europe.

Yet in Europe, the tendency to increase is always very strongly marked, and the actual increase for periods of some length is sometimes much greater than could be expected beforehand, considering the obstacles to be overcome.

It appears from Sussmilch,* that the population of Prussia and Lithuania, after the great plague in 1709 and 1710, doubled itself in about 44 years, from the excess of the births above the deaths enumerated in the registers.

In Russia, the whole population in 1763 was estimated, by enumeration and calculation, at twenty millions, and in 1796 at thirty-six millions.† This is a rate of increase which would occasion a doubling in less than 42 years.

In 1695, the population of Ireland was estimated at 1,034,000. According to the late returns in 1821, it had increased to the prodigious amount of 6,846,949 : ‡ and it is thought that when the deficiencies have been supplied by the final returns of the numerators, it will be upwards of seven millions. This is an example of an actual increase for 125 years together, at a rate which would double the population in about 45 years; and this has taken place under the frequent pressure of great distress among the labouring classes of society, and the practice of frequent and considerable emigration.

But for the proof of the power of population to increase under great obstacles of the preventive, as well as of the positive kind, we need not go out of Great Britain. The rate of increase since our enumerations have commenced has been very remarkable for a country which was considered as well peopled before, and some of the details accompanying the returns tend strikingly to illustrate the principle of population.

Increase of the Population of Great Britain from 1800 to 1821.

The population of Great Britain, according to the late enumerations, was, in 1801, 10,942,646, and, in 1811, 12,596,803.§ This is a rate of increase, during the ten years, of rather above 15 *per cent.*, a rate which, if continued, would double the population in between 49 and 50 years.

By the last enumeration of 1821, it appears that the population was 14,391,631, || which, compared with the population of 1811, gives a rate of increase during the ten years of 14.25 *per cent.*, a rate which would double the population in about 52 years.

According to these numbers, the rate of increase during the last ten years was slower than that of the first; but it appears from the excess of the number of males above females in the enumeration of 1811, so opposite to the state of the population in 1801 and 1821, when the females exceeded the males, particularly at the latter period, that of the large number added to the population for the army, navy, and registered merchant ships in 1811, a considerable proportion must have been foreigners. On this account, and on account of the further difficulty of knowing what part of this number might properly belong to Ireland, it has been proposed to estimate the rate *per cent.* at which the population has increased in each of the ten years by the females only; and according to this mode of computation the population increased during the first period at the rate of 14.02 *per cent.*, and during the second at the rate of 15.82.—(*Preliminary Observations*, p. 8.) This last rate of increase would double the population in less than 48 years.

The only objection to this mode of computation is, that it does not take into consideration the greater destruction of the males during the war. In 1801, the females exceeded the half of the population by 21,031, and in 1821 by 63,890, while, at the intermediate period, owing to the causes above mentioned, the females fell short of the half of the males by 35,685.

When, however, a proper distribution has been made of the army and navy among the resident population, and taking England and Wales alone, it appears that from 1801 to 1811 the population increased at the rate of $14\frac{1}{2}$ *per cent.*, and from 1811 to 1821, at the rate of $16\frac{1}{3}$ *per cent.*—(*Preliminary Observations*, p. 32.) At the former of these rates, the period of doubling would be rather above 50 years—at the latter, under 46 years, and taking the whole period, the time of doubling would be about 48 years. Yet in Great Britain, there is a much larger proportion of the population living in towns, and engaged in occupations considered as unhealthy, than in any other known country of the same extent. There are also the best reasons for believing that in no other country of the same extent is there to be found so great a proportion of late marriages, or so great a proportion of persons remaining unmarried, as in Great Britain. It is further known that the number of emigrants from Great Britain greatly exceed those who come into the country. And if, under these circumstances, a demand for labour and an increase of the funds for its maintenance, could for 20 years together occasion such a rate of increase, as, if continued, would double the population in 48 years, and quadruple it in 96 years, it is in the highest degree probable, that if the encouragements to marriage and the means of supporting a family were as great as in America, the period of doubling in Great Britain would not be more than 25 years, even in spite of her great towns and manufactories; and would be decidedly less if these obstacles were removed.

* *Gotliche Ordnung*, Vol. I. Table XXI.
† Malthus *On Population*, Vol. I. p. 439, 5th edit.
‡ *Report* of the Preliminary Proceedings under Population Act, 58th Geo. III. p. 28.
§ *Population Abstract*, 1821. *Preliminary Observations*, p. 8.
|| *Ibid.*

Population.

The Lowest Rate of Increase which can, with any probability, be assumed for the natural Progress of Population.

Taking, therefore, into consideration the actual rate of increase, which appears from the best documents to have taken place over a very large extent of country in the United States of America, very variously circumstanced as to healthiness and rapidity of progress; considering further, the rate of increase which has taken place in New Spain, and also in many countries of Europe, where the means of supporting a family, and other circumstances favourable to increase, bear no comparison with those of the United States; and adverting particularly to the great increase of population which has taken place in this country during the last 20 years, under the formidable obstacles to its progress which must press themselves upon the attention of the most careless observer, it must appear, that the assumption of a rate of increase such as would double the population in 25 years, as representing the natural progress of population, when not checked by the difficulty of procuring the means of subsistence, or other peculiar causes of premature mortality, must be very decidedly within the truth.

It may be safely asserted, therefore, that population, when unchecked, increases in a geometrical progression of such a nature as to double itself every twenty-five years.

Different Character of the Rate of Increase in the Food of a Limited Territory.

It would be unquestionably desirable to have the means of comparing the natural rate of the increase of population when unchecked, with the possible rate of the increase of food, in a limited territory, such as that in which man is actually placed; but the latter estimate is much more difficult and uncertain than the former. If the rate of the increase of population at a particular period of some little extent can be ascertained with tolerable exactness, we have only to suppose the continuance of the same encouragements to marriage, the same facility of supporting a family, the same moral habits, with the same rate of mortality, and the increase of the population at the same rate, after it had reached a thousand millions, would be just as probable as at any intermediate and earlier period; but it is quite obvious that the increase of food in a limited space must proceed upon a principle totally different. It has been already stated, that while land of good quality is in great abundance, the rate at which food might be made to increase would far exceed what is necessary to keep pace with the most rapid increase of population which the laws of nature in relation to human kind permit. But if society were so constituted as to give the fullest scope possible to the progress of cultivation and population, all such lands, and all lands of moderate quality, would soon be occupied; and when the future increase of the supply of food came to depend upon the taking of very poor land into cultivation, and the gradual and laborious improvement of the land already cultivated, the rate of the increase of food would certainly have a greater resemblance to a decreasing geometrical ratio than an increasing one. The yearly increment of food would, at any rate, have a constant tendency to diminish, and the amount of the increase of each successive ten years would probably be less than that of the preceding.

Practically, however, great uncertainty must take place. An unfavourable distribution of produce, by prematurely diminishing the demand for labour, might retard the increase of food at an early period, in the same manner as if cultivation and population had been further advanced; while improvements in agriculture, accompanied by a great demand for labour and produce, might for some time occasion a rapid increase of food and population at a later period, in the same manner as if cultivation and population had been in an earlier stage of their progress. These variations, however, obviously arise from causes which do not impeach the general *tendency* of a continued increase of produce in a limited territory to diminish the *power* of its increase in future.

Supposition respecting the Power of increasing Food.

Under this certainty with regard to the general *tendency*, and uncertainty in reference to particular periods, it must be allowable, if it throws light on the subject, to make a supposition respecting the increase of food in a limited territory, which, without pretending to accuracy, is clearly more favourable to the power of the soil to produce the means of subsistence for an increasing population, than any experience which we have of its qualities will warrant.

If, setting out from a tolerably well peopled country such as England, France, Italy, or Germany, we were to suppose that, by great attention to agriculture, its produce could be permanently increased every twenty-five years by a quantity equal to that which it at present produces, it would be allowing a rate of increase decidedly beyond any probability of realization. The most sanguine cultivators could hardly expect that, in the course of the next two hundred years, each farm in this country on an average would produce eight times as much food as it produces at present, and still less that this rate of increase could continue, so that each farm would produce twenty times as much as at present in 500 years, and forty times as much in 1000 years. Yet this would be an arithmetical progression, and would fall short, beyond all comparison, of the natural increase of population in a geometrical progression, according to which the inhabitants of any country in 500 years, instead of increasing to twenty times, would increase to above a million times their present numbers.

It will be said, perhaps, that many parts of the earth are as yet very thinly peopled, and, under proper management, would allow of a much more rapid increase of food than would be possible in the more fully inhabited states of Europe. This is unquestionably true. Some parts of the earth would no doubt be capable of producing food at such a rate as to keep pace for a few periods with an unrestricted increase of population. But, to put this capacity fully into action, is of all things the most difficult. If it is to be accomplished by the improvement of the actual inhabitants of the different parts of the earth in knowledge, in government, in industry, in arts, and in morals, it is scarcely possible to say how it ought to be commenced with the best prospect of success, or to form a conjecture as to the time in which it could be effected.

Insufficiency of Emigration.

If it is to be accomplished by emigration from the more improved parts of the world, it is obvious that it must involve much war and extermination; besides all the difficulties usually attendant upon new

settlements in uncivilized countries; and these alone are so formidable, and for a long time so destructive, that, combined with the unwillingness which people must always naturally feel to quit their own country, much distress would be suffered at home before relief would be sought for in emigration.

But, supposing for a moment that the object could be fully accomplished, that is, supposing that the capacity of the earth to produce the necessaries of life could be put fully into action, and that they were distributed in the proportions most favourable for the growth of capital, and the effective demand for labour, the increase of population, whether arising from the increase of the inhabitants of each country, or from emigrants issuing from all those countries which were more advanced in cultivation, would be so rapid, that, in a period comparatively quite short, all the good lands would be occupied, and the rate of the possible increase of food would be reduced much below the arithmetical ratio above supposed.

If, merely during the short period which has elapsed since our Revolution of 1688, the population of the earth had increased at its natural rate when unchecked, supposing the number of people at that time to have been only 800 millions, all the land of the globe, without making allowance for deserts, forests, rocks, and lakes, would on an average be equally populous with England and Wales at present. This would be accomplished in five doublings, or 125 years; and one or two doublings more, or a period less than that which has elapsed since the beginning of the reign of James the First, would produce the same effect from the overflowings of the inhabitants of those countries, where, owing to the further progress of cultivation, the soil had not the capacity of producing food so as to keep pace with the increase of an unrestricted population.

Whatever temporary and partial relief, therefore, may be derived from emigration by particular countries in the actual state of things, it is quite obvious, that, considering the subject generally and largely, emigration may be fairly said not in any degree to touch the difficulty. And, whether we exclude or include emigration,—whether we refer to particular countries, or to the whole earth, the supposition of a future capacity in the soil to increase the necessaries of life every twenty-five years by a quantity equal to that which is at present produced, must be decidedly beyond the truth.

Effect of the two different Rates of Increase when brought together.

But, if the natural increase of population, when unchecked by the difficulty of procuring the means of subsistence, or other peculiar causes, be such as to continue doubling its numbers in twenty-five years; and the greatest increase of food, which, for a continuance, could possibly take place on a limited territory like our earth in its present state, be at the most only such as would add every twenty-five years an amount equal to its present produce; it is quite clear that a powerful check on the increase of population must be almost constantly in action.

By the laws of nature man cannot live without food. Whatever may be the rate at which population would increase if unchecked, it never can actually increase in any country beyond the food necessary to support it. But, by the laws of nature in respect to the powers of a limited territory, the additions which can be made in equal periods to the food which it produces must, after a short time, either be constantly decreasing, which is what would really take place; or, at the very most, must remain stationary, so as to increase the means of subsistence only in an arithmetical progression. Consequently, it follows necessarily that the average rate of the *actual* increase of population over the greatest part of the globe, obeying the same laws as the increase of food, must be totally of a different character from the rate at which it would increase if *unchecked*.

General character of the *Checks* to Population.

The great question, then, which remains to be considered, is the manner in which this constant and necessary check upon population practically operates.

If the soil of any extensive well peopled country were equally divided amongst its inhabitants, the check would assume its most obvious and simple form. Perhaps each farm in the well peopled countries of Europe might allow of one, or even two doublings, without much distress, but the absolute impossibility of going on at the same rate is too glaring to escape the most careless thinker. When, by extraordinary efforts, provision had been made for four times the number of persons which the land can support at present, what possible hope could there be of doubling the provision in the next twenty-five years?

Yet there is no reason whatever to suppose that any thing besides the difficulty of procuring in adequate plenty the necessaries of life, should either indispose this greater number of persons to marry early, or disable them from rearing in health the largest families. But this difficulty would of necessity occur, and its effect would be either to discourage early marriages, which would check the rate of increase by preventing the same proportion of births; or to render the children unhealthy from bad and insufficient nourishment, which would check the rate of increase by occasioning a greater proportion of deaths; or, what is most likely to happen, the rate of increase would be checked, partly by the diminution of births, and partly by the increase of mortality.

The first of these checks may, with propriety, be called the *preventive check* to population; the second, the *positive check*; and the absolute necessity of their operation in the case supposed is as certain and obvious as that man cannot live without food.

Taking a single farm only into consideration, no man would have the hardihood to assert that its produce could be made permanently to keep pace with a population increasing at such a rate as it is observed to do for 20 or 30 years together at particular times and in particular countries. He would, indeed, be compelled to acknowledge, that if, with a view to allow for the most sanguine speculations, it has been supposed that the additions made to the necessaries produced by the soil in given times might remain constant, yet that this rate of the increase of produce could not possibly be realized; and that, if the capacity of the soil were at all times put properly into action, the additions to the pro-

duce would, after a short time, and independently of new inventions, be constantly decreasing, till, in no very long period, the exertions of an additional labourer would not produce his own subsistence.

But what is true, in this respect, in reference to a single farm, must necessarily be true of the whole earth, from which the necessaries of life for the actual population are derived. And what would be true in respect to the checks to population, if the soil of the earth were equally divided among the different families which inhabit it, must be true, under the present unequal division of property, and variety of occupations. Nothing but the confusion and indistinctness arising from the largeness of the subject, and the vague and false notions which prevail respecting the efficacy of emigration, could make persons deny in the case of an extensive territory, or the whole earth, what they could not fail to acknowledge in the case of a single farm which may be said fairly to represent it.

It may be expected, indeed, that in civilized and improved countries, the accumulation of capital, the division of labour, and the invention of machinery, will extend the bounds of production; but we know from experience, that the effects of these causes, which are quite astonishing in reference to some of the *conveniences* and *luxuries* of life, are very much less efficient in producing an increase of *food;* and although the saving of labour and an improved system of husbandry may be the means of pushing cultivation upon much poorer lands than could otherwise be worked; yet the increased quantity of the necessaries of life so obtained can never be such as to supersede, for any length of time, the operation of the preventive and positive checks to population. And not only are these checks as absolutely necessary in civilized and improved countries, as they would be, if each family had a certain portion of land allotted to it, but they operate almost exactly in the same way. The distress which would obviously arise in the most simple state of society from the natural tendency of population to increase faster than the means of subsistence in a limited territory, is brought home to the higher classes of an improved and populous country in the difficulty which they find in supporting their families in the same rank of life with themselves; and to the labouring classes which form the great mass of society, in the insufficiency of the real wages of common labour to bring up a large family.

If in any country the yearly earnings of the commonest labourers determined, as they always will be, by the state of the demand and the supply of necessaries compared with labour, be not sufficient to bring up in health the largest families, one of the three things before stated must happen; either the prospect of this difficulty will prevent some and delay other marriages; or the diseases arising from bad nourishment will be introduced, and the mortality be increased; or the progress of population will be retarded, partly by one cause and partly by the other.

Of the Effect of Private Property on the Progress of Population.

According to all past experience, and the best observations which can be made on the motives which operate upon the human mind, there can be no well founded hope of obtaining a large produce from the soil, but under a system of private property. It seems perfectly visionary to suppose that any stimulus short of that which is excited in man by the desire of providing for himself and family, and of bettering his condition in life, should operate on the mass of society with sufficient force and constancy to overcome the natural indolence of mankind. All the attempts which have been made since the commencement of authentic history to proceed upon a principle of common property, have either been so insignificant that no inference can be drawn from them, or have been marked by the most signal failures; and the changes which have been effected in modern times by education, do not seem to advance a single step towards making such a state of things more probable in future. We may, therefore, safely conclude that while man retains the same physical and moral constitution which he is observed to possess at present, no other than a system of private property stands the least chance of providing for such a large and increasing population as that which is to be found in many countries at present.

But though there is scarcely any conclusion which seems more completely established by experience than this, yet it is unquestionably true that the laws of private property, which are the grand stimulants to production, do themselves so limit it, as always to make the actual produce of the earth fall very considerably short of the *power* of production. On a system of private property no adequate motive to the extension of cultivation can exist, unless the returns are sufficient not only to pay the wages necessary to keep up the population, which, at the least, must include the support of a wife and two or three children, but also afford a profit on the capital which has been employed. This necessarily excludes from cultivation a considerable portion of land, which might be made to bear corn. If it were possible to suppose that man might be adequately stimulated to labour under a system of common property, such land might be cultivated, and the production of food and the increase of population might go on, till the soil absolutely refused to grow a single additional quarter, and the whole of the society was exclusively engaged in procuring the necessaries of life. But it is quite obvious that such a state of things would inevitably lead to the greatest degree of distress and degradation. And, if a system of private property secures mankind from such evils, which it certainly does, in a great degree, by securing to a portion of the society the leisure necessary for the progress of the arts and sciences, it must be allowed that such a check to the increase of cultivation confers on society a most signal benefit.

But it must perhaps also be allowed, that, under a system of private property, cultivation is sometimes checked in a degree, and at a period, not required by the interest of society. And this is particularly likely to happen when the original divisions of land have been extremely unequal, and the laws have not given sufficient facility to a better distribution of them. Under a system of private property, the only effectual demand for produce must come from the owners of property; and though it be true that the effectual demand of the society, whatever it may be,

is best supplied under the most perfect system of liberty, yet it is not true that the tastes and wants of the effective demanders are always, and necessarily, the most favourable to the progress of national wealth. A taste for hunting and the preservation of game among the owners of the soil will, without fail, be supplied, if things be allowed to take their natural course; but such a supply, from the manner in which it must be effected, would inevitably be most unfavourable to the increase of produce and population. In the same manner, the want of an adequate taste for the consumption of manufactured commodities among the possessors of surplus produce, if not fully compensated by a great desire for personal attendance, which it never is, would infallibly occasion a premature slackness in the demand for labour and produce, a premature fall of profits, and check to cultivation.

It makes little difference in the actual rate of the increase of population, or the necessary existence of checks to it, whether that state of demand and supply which occasions an insufficiency of wages to the whole of the labouring classes be produced prematurely by a bad structure of society, and an unfavourable distribution of wealth, or necessarily by the comparative exhaustion of the soil. The labourer feels the difficulty nearly in the same degree, and it must have nearly the same results, from whatever cause it arises; consequently, in every country with which we are acquainted, where the yearly earnings of the labouring classes are not sufficient to bring up in health the largest families, it may be safely said, that population is actually checked by the difficulty of procuring the means of subsistence. And, as we well know that ample wages, combined with full employment for all who choose to work, are extremely rare, and scarcely ever occur, except for a certain time, when the knowledge and industry of an old country is applied, under favourable circumstances, to a new one; it follows, that the pressure arising from the difficulty of procuring subsistence is not to be considered as a remote one, which will be felt only when the earth refuses to produce any more, but as one which not only actually exists at present over the greatest part of the globe, but, with few exceptions, has been almost constantly acting upon all the countries of which we have any account.

It is unquestionably true, that, in no country of the globe have the government, the distribution of property, and the habits of the people, been such as to call forth, in the most effective manner, the resources of the soil. Consequently, if the most advantageous possible change in all these respects could be supposed at once to take place, it is certain that the demand for labour, and the encouragement to production, might be such, as for a short time, in some countries, and for rather a longer in others, to lessen the operation of the checks to population which have been described. It is specifically this truth constantly obtruding itself upon our attention, which is the great source of delusion on this subject, and creates the belief that man could always produce from the soil much more than sufficient to support himself and family. In the actual state of things, this power has perhaps always been possessed. But for it we are indebted wholly to the ignorance and bad government of our ancestors. If they had properly called forth the resources of the soil, it is quite certain that we should now have but scanty means left of further increasing our food. If merely since the time of William the Conqueror, all the nations of the earth had been well governed, and, if the distribution of property, and the habits both of the rich and the poor had been the most favourable to the demand for produce and labour, though the amount of food and population would have been prodigiously greater than at present, the means of diminishing the checks to population would unquestionably be less. That difficulty in procuring the necessaries of life which is now felt in the comparatively low wages of labour almost all over the world, and is occasioned partly by the necessary state of the soil, and partly by a premature check to the demand for produce and labour, would then be felt in a greater degree, and would less admit of any relaxation in the checks to population, because it would be occasioned wholly and necessarily by the state of the soil.

The Laws of Nature responsible for the necessity of checks to Population.

It appears, then, that what may be called the proportionate amount of the necessary checks to population depends very little upon the efforts of man in the cultivation of the soil. If these efforts had been directed from the first in the most enlightened and efficient manner, the checks necessary to keep the population on a level with the means of subsistence, so far from being lightened, would in all probability be operating with greater force; and the condition of the labouring classes, so far as it depends on the facility of procuring the means of subsistence, instead of being improved, would in all probability be deteriorated.

It is to the laws of nature, therefore, and not to the conduct and institutions of man, that we are to attribute the necessity of a strong check on the natural increase of population.

Man responsible for the scanty Population of the Earth, and the prevailing character of the Checks to it.

But, though the laws of nature which determine the rate at which population would increase if unchecked, and the very different rate at which the food required to support population could be made to increase in a limited territory, are undoubtedly the causes which render necessary the existence of some great and constant check to population, yet a vast mass of responsibility remains behind on man and the institutions of society.

In the first place, they are certainly responsible for the present scanty population of the earth. There are few large countries, however advanced in improvement, the population of which might not have been doubled or tripled, and there are many which might be ten, or even a hundred times as populous, and yet all the inhabitants be as well provided for as they are now, if the institutions of society, and the moral habits of the people, had been for some hundred years the most favourable to the increase of capital, and the demand for produce and labour.

Secondly, Though man has but a trifling and temporary influence in altering the proportionate amount of the checks to population, or the degree in which

they press upon the actual numbers, yet he has a great and most extensive influence on their character and mode of operation.

It is not in superseding the necessity of checks to population, in the progress of mankind to the full peopling of the earth (which may with truth be said to be a physical impossibility), but in directing these checks in such a way as to be the least prejudicial to the virtue and happiness of society, that government and human institutions produce their great effect. Here we know, from constant experience, that they have great power. Yet, even here it must be allowed, that the power of Government is rather indirect than direct, as the object to be attained depends mainly upon such a conduct on the part of individuals, as can seldom be directly enforced by laws, though it may be powerfully influenced by them.

This will appear, if we consider more particularly the nature of those checks which have been classed under the generalheads of Preventive and Positive.

The Positive and Preventive Checks resolvable into Moral Restraint, Vice, and Misery.

It will be found that they are all resolvable into *moral restraint, vice*, and *misery*. And if, from the laws of nature, some check to the increase of population be absolutely inevitable, and human institutions have any influence upon the extent to which each of these checks operates, a heavy responsibility will be incurred, if all that influence, whether direct or indirect, be not exerted to diminish the amount of vice and misery.

Moral restraint, in application to the present subject, may be defined to be, abstinence from marriage, either for a time or permanently, from prudential considerations, with a strictly moral conduct towards the sex in the interval. And this is the only mode of keeping population on a level with the means of subsistence, which is perfectly consistent with virtue and happiness. All other checks, whether of the preventive or the positive kind, though they may greatly vary in degree, resolve themselves into some form of vice or misery.

The remaining checks of the preventive kind, are the sort of intercourse which renders some of the women of large towns unprolific; a general corruption of morals with regard to the sex, which has a similar effect; unnatural passions and improper arts to prevent the consequences of irregular connections. These evidently come under the head of vice.

The positive checks to population include all the causes, which tend in any way prematurely to shorten the duration of human life; such as unwholesome occupations—severe labour and exposure to the seasons—bad and insufficient food and clothing arising from poverty—bad nursing of children—excesses of all kinds—great towns and manufactories—the whole train of common diseases and epidemics—wars, infanticide, plague, and famine. Of these positive checks, those which appear to arise from the laws of nature, may be called exclusively misery; and those which we bring upon ourselves, such as wars, excesses of all kinds, and many others, which it would be in our power to avoid, are of a mixed nature. They are brought upon us by vice, and their consequences are misery.

Some of these checks, in various combinations, and operating with various force, are constantly in action in all the countries with which we are acquainted, and form the immediate causes which keep the population on a level with the means of subsistence.

Mr Malthus, in his work on this subject, has taken a view of the checks of population in most of the countries of which we have the best accounts. His object was evidently to trace in each country those checks which appeared to be most effective in repressing population; and to endeavour to answer the question, generally, which had been applied, particularly, to New Holland by Captain Cook, namely, By what means is the population of this country kept down to the number which it can subsist?

Prudential Restraint on Marriage.

It was hardly to be expected, however, that the general accounts of countries which are to be met with, should countain a sufficient number of details of the kind required, to enable us to ascertain what portion of the natural increase of population each individual check which could be traced, had the power to overcome. In particular, it was not to be expected, that any accounts could inform us of the degree in which moral restraint prevails, when taken in its strictest sense. It is necessary, therefore, to attend chiefly to the greater or smaller number of persons who remain unmarried or marry late; and the delay of marriage, owing to the difficulty of providing for a family, when the degree of irregularity to which it may lead cannot be ascertained, may be usefully called the prudential restraint on marriage and population. And this will be found to be the chief mode in which the preventive check practically operates.

Causes which principally affect the Habits of the Labouring Classes of Society.

But if the preventive check to population, that check which can alone supersede great misery and mortality, operates chiefly by a prudential restraint on marriage, it will be obvious, as was before stated, that direct legislation cannot do much. Prudence cannot be enforced by laws, without a great violation of natural liberty, and a great risk of producing more evil than good. But still, the very great influence of a just and enlightened government, and the perfect security of property in creating habits of prudence, cannot for a moment be questioned. The principal causes and effects of these habits are thus stated in Mr Malthus's last work. (*Principles of Political Economy*, c. iv. sec. 2.)

"From high wages, or the power of commanding a large portion of the necessaries of life, two very different results may follow; one, that of a rapid increase of population, in which case, the high wages are chiefly spent in the maintenance of large and frequent families; and the other, that of a decided improvement in the modes of subsistence, and the conveniences and comforts enjoyed, without a proportionate acceleration in the rate of increase.

"In looking to these different results, the causes of them will evidently appear to be the different habits existing among the people of different countries, and at different times. In an inquiry into the

causes of these different habits, we shall generally be able to trace those which produce the first result to all the circumstances which contribute to depress the lower classes of tbe people, which make them unable or unwilling to reason from the past to the future, and ready to acquiesce for the sake of present gratification, in a very low standard of comfort and respectability; and those which produce the second result, to all the circumstances which tend to elevate the character of the lower classes of society, which make them approach the nearest to beings who "look before and after," and who, consequently, cannot acquiesce patiently in the thought of depriving themselves and their children of the means of being respectable, virtuous, and happy.

"Among the circumstances which contribute to the character first described, the most efficient will be found to be despotism, oppression, and ignorance; among those which contribute to the latter character, civil and political liberty, and education.

"Of all the causes which tend to encourage prudential habits among the lower classes of society, the most essential is unquestionably civil liberty. No people can be much accustomed to form plans for the future, who do not feel assured that their industrious exertions, while fair and honourable, will be allowed to have free scope; and that the property which they either possess or may acquire, will be secured to them by a known code of just laws impartially administered. But it has been found by experience, that civil liberty cannot be permanently secured without political liberty. Consequently, political liberty becomes almost equally essential: and in addition to its being necessary in this point of view, its obvious tendency to teach the lower classes of society to respect themselves, by obliging the higher classes to respect them, must contribute greatly to all the good effects of civil liberty."

"With regard to education, it might certainly be made general under a bad form of government, and might be very deficient under one in other respects good; but it must be allowed that the chances, both with regard to its quality and its prevalence, are greatly in favour of the latter. Education alone could do little against insecurity of property; but it would powerfully assist all the favourable consequences to be expected from civil and political liberty, which could not indeed be considered as complete without it."

The varying prevalence of these habits, owing to the causes above referred to, combined with the smaller or greater mortality occasioned by other customs, and the varying effects of soil and climate, must necessarily produce great differences in different countries, and at different periods, in the character of the predominant checks to population and the force of each. And this inference, which inevitably follows from theory, is fully confirmed by experience.

The Positive Checks to Population predominated in Ancient Times.

It appears, for instance, from the accounts we have received of ancient nations, and of the less civilized parts of the world, that war and violent diseases were the predominant checks to their population. The frequency of wars, and the dreadful devastations of mankind occasioned by them, united with the plagues, famines, and mortal epidemics of which there are records, must have caused such a consumption of the human species, that the exertion of the utmost power of increase must, in many cases, have been insufficient to supply it; and we see at once the source of those encouragements to marriage, and efforts to increase population, which, with inconsiderable exceptions, distinguished the legislation, and general policy of ancient times. Yet there were some few men of more extended views who, when they were looking to the settlement of a society in a more improved state, were fully aware, that under the most beautiful form of government which their imagination could conceive, the greatest poverty and distress might be felt from a too rapid increase of population. And the remedies which they proposed were strong and violent in proportion to the greatness of the evil which they apprehended. Even the practical legislators who encouraged marriage, seemed to think that the supplies of children might sometimes follow too rapidly for the means of supporting them; and it appears to have been with a view to provide against this difficulty, and of preventing it from discouraging marriage, that they frequently sanctioned the inhuman practice of infanticide.

Under these circumstances, it is not to be supposed that the prudential restraint on marriage should have operated to any considerable extent. Except in a few cases where a general corruption of morals prevailed which might aet as a preventive check of the most vicious kind, a large portion of the procreative power was called into action, the occasional redundancy from which was checked by violent causes. These causes will be found resolvable almost wholly into vice and misery; the first of which, and a large portion of the second, it is always in the power of man to avoid.

Prudential Restraint the predominant Check to Population in Modern Times.

In a review of the checks to population in the different states of modern Europe, it appears that the positive checks to population have prevailed less, and the preventive checks more, than in ancient times, and in the more uncultivated parts of the world. The destruction occasioned by war has unquestionably abated, both on account of its occurring, on the whole, less frequently, and its ravages not being so fatal, either to man or the means of his support, as they were formerly. And although, in the earlier periods of the history of modern Europe, plagues, famines, and mortal epidemics were not unfrequent; yet as civilization and improvement have advanced, both their frequency and their mortality have been greatly reduced, and in some countries they are now almost unknown. This diminution of the positive checks to population, as it has been certainly much greater in proportion than the actual increase of food and population, must necessarily have been accompanied by an increasing operation of the preventive checks; and probably it may be said with truth, that in almost all the more improved countries of modern Europe, the principal check which at pre-

sent keeps the population down to the level of the actual means of subsistence, is the prudential restraint on marriage.

Difference in the Character and Force of the Checks in different Countries.

Yet in comparing together the accounts and registers of the different countries of modern times, we shall still find a vast difference in the character and force of the checks which are mainly in action; and it is precisely in this point of view that these accounts afford the most important instruction. Some parts of Europe are yet in an unimproved state, and are still subject to frequent plagues and mortal epidemics. In these countries, as might be expected, few traces are to be found of the prudential restraint on marriage. But even in improved countries, the circumstances may be such as to occasion a great mortality. Large towns are known to be unfavourable to health, particularly to the health of young children; and the unwholesomeness of marshy situations may be such as in some cases to balance the principle of increase, even when nearly the whole of the procreative power is called into action, which is seldom the case, in large towns.

Thus in the registers of twenty-two Dutch villages given by Sussmilch,* and quoted by Mr Malthus, the mortality (occasioned, as may be supposed, chiefly by the natural unhealthiness of the country) was as high as one in twenty-two or twenty-three, instead of the more common proportion of one in thirty-five or forty; and the consequence was, that the marriages, instead of being in the usual proportion of one in about 108 of the population, were in the extraordinary high proportion of one in sixty-four; † showing a most unusual frequency of marriage, while, on account of the great mortality, the number of inhabitants was nearly stationary, and the births and deaths about equal.

On the other hand, in Norway, where the climate and modes of living seem to be extremely favourable to health, and the mortality was only one in forty-eight, the prudential restraint on marriage was called more than usually into action, and the marriages were only one in 130 of the population. (Malthus, Vol. I. p. 365, 5th ed.)

Gradual Diminution in the Proportion of Marriages.

These may be considered as extreme cases, but the same result in different degrees is observable in the registers of all countries; and it is particularly to be remarked, that in those countries where registers of births, deaths, and marriages have been kept for a considerable time, the progressive diminution of mortality occasioned by the introduction of habits more favourable to health, and the consequent diminution of plagues and mortal epidemics, have been accompanied invariably by a smaller proportion of marriages and births. Sussmilch has given some striking instances of the gradual diminution in the proportion of the number of marriages during a part of the last century. (*Gottliche Ordnung*, Vol. I. pp. 134, *et seq.*)

In the town of Leipsic, in the year 1620, the annual marriages were to the population as 1 to 82; from the year 1741 to 1756, they were as 1 to 120.

In Augsburgh, in 1510, the proportion of marriages to the population was 1 in 86; in 1750 as 1 to 123.

In Dantzic, in the year 1705, the proportion was as 1 to 89; in 1745, as 1 to 118.

In the Dukedom of Magdeburgh, in 1700, the proportion was as 1 to 87; from 1752 to 1755, as 1 to 125.

In the principality of Halberstadt, in 1690, the proportion was as 1 to 88; in 1756, as 1 to 112.

In the Dukedom of Cleves, in 1705, the proportion was 1 to 83; in 1755, 1 to 100.

In the Churmark of Brandenburgh, in 1700, the proportion was 1 to 76; in 1755, 1 to 108.

Instances of this kind are numerous, and they tend to show the dependence of the marriages on the deaths in all old countries. A greater mortality almost invariably produces a greater number of marriages; and it must be equally certain, that except where the means of subsistence can be adequately increased, a greater proportion of marriages must occasion a greater mortality.

Dependence of the Births and Marriages on the Deaths.

The proportion of yearly births to the whole population, must evidently depend principally on the proportion of marriages; and it appears, consequently, from registers, that in countries which will not admit of any considerable increase of population, the births, as well as the marriages, are mainly influenced by the deaths. When an actual decrease of population is not taking place, the births will always supply the vacancies made by death, and exactly so much more as the increasing wealth of the country and the demand for labour will admit. Every where in the intervals of plagues, epidemics, and destructive wars, the births considerably exceed the deaths; but while from these and other causes the mortality in different countries is extremely various, it appears from registers that, with the exception above stated, the births vary in the same proportion. ‡

Thus, in 39 villages of Holland, where the deaths, at the time to which the registers refer, were about 1 in 23, the births were also 1 in 23. In 15 villages round Paris, the births bore the same, or even a greater proportion to the whole population, on account of a still greater mortality, the births being 1 in $22\frac{7}{10}$, and the deaths the same. In the small towns of Brandenburgh, which were in an increasing state, the mortality was 1 in 29, and the births 1 in $24\frac{7}{10}$. In Sweden, where the mortality was about 1 in $34\frac{1}{2}$, the births were 1 in 28. In 1056 villages of Brandenburgh, in which the mortality was about 1 in 39 or 40; the births were about 1 in 30. In Norway,

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* *Gottliche Ordnung*, Vol. I. c. iv. s. 57, p. 128.—Malthus' *Essay on Population*, B. II. c. iv. p. 444 of Vol. I. 5th edition.

† This very large proportion of marriages could not all have been supplied from the births in the country, but must have been occasioned in part by the influx of strangers.

‡ Sussmilch, *Gottliche Ordnung*, Vol. I. p. 225.—*Essay on Population*, Vol. I. p. 456, 5th ed.

where the mortality was 1 in 48, the births were 1 in 34.

In all these instances the births are evidently measured by the deaths, after making a proper allowance for the excess of births which the state of each country will admit. In such a country as Russia, this allowance must be great; as although the mortality might perhaps be taken as low as 1 in 48 or 50; the births were as high as 1 in 26, owing to the increasing resources of the country which admit of a rapid increase of the population.

Dependence of the Births on the Deaths strikingly illustrated in Switzerland.

Of all the countries which Mr Malthus has reviewed, there is none which so strikingly illustrates the most important fact of the dependence of the proportions of marriages and births on the deaths, and the general principles of population, as Switzerland. It appears, that between 1760 and 1770, an alarm prevailed respecting the continued depopulation of the country; and to ascertain the point, M. Muret, minister of Vevay, made a very laborious and careful search into the registers of different parishes from the time of their first establishment. He compared the number of births which had taken place during three different periods of 70 years each, the first ending in 1620, the second in 1690, and the third in 1760. And finding by this comparison, that the number of births was less in the second period than in the first, and less in the third period than in the second, he considered the evidence of a continued depopulation of the country from the year 1055 as incontrovertible.* But the accounts which he himself produces, clearly show that, in the earlier periods to which he refers, the mortality was very much greater than in the latter; and, that the greater *number* of births found in the registers formerly, was not owing to a greater population, but to the greater *proportion* of births which always accompanies a greater mortality.

It appears from accounts, which are entirely to be depended on, that during the last period, the mortality was extraordinarily small, and the proportion of children reared from infancy to puberty extraordinary great. At the time when M. Muret wrote his paper, in 1766, the proportion of deaths to the population in the Pays de Vaud, was 1 in 45, of births 1 in 36, and of marriages 1 in 140. These are all very small proportions of births, deaths, and marriages, compared with other countries; but the state of things must have been totally different in the sixteenth and seventeenth centuries. M. Muret gives a list of all the plagues which had prevailed in Switzerland from 1520, from which it appears that this dreadful scourge desolated the country at short intervals during the whole of the first period, and extended its occasional ravages to within 22 years of the termination of the second. We may safely conclude, that, in these times, the average mortality was very much greater than at present. But what puts the question beyond a doubt, is the great mortality which prevailed in the neighbouring town of Geneva in the sixteenth century, and its gradual diminution in the seventeenth and eighteenth. It appears from calculations, published in the *Bibliotheque Britannique*, (Tom. IV. p. 328,) that in the sixteenth century, the probability of life, or the age to which half of the born lived, was only 4.883, or under four years and eleven months; and the mean life, or the average number of years due to each person 18.511, or about eighteen years and a half. In the seventeenth century, the probability of life in Geneva was 11.607, about eleven years and seven months; the mean life 23.358, or twenty-three years and four months. In the eighteenth century, the probability of life had increased to 27.183, twenty-seven years and two months; and the mean life to thirty-two years and two months.

There can be no doubt, from the prevalence of the plague, and its gradual extinction as noticed by M. Muret, that a diminution of mortality of the same kind, though not perhaps to the same extent, must have taken place in Switzerland; but if with a mortality, which could not have been less than 1 in 30 or 32, the proportion of births had been what it was when M. Muret wrote, it is quite evident that the country would have been rapidly depopulated. But as it is known, from the actual amount of births found in the registers, that this was not the case, it follows as a necessary consequence, that the greater mortality of former times was accompanied by a greater proportion of births. And this at once shows the error of attempting to determine the actual population, either of different countries, or of different periods in the same country, by the amount of the births; and the strong tendency of population to fill up all vacancies, and very rarely to be limited by any other cause than the difficulty of supporting a family.

Switzerland and the Pays de Vaud afford other most striking instances of the dependence of the births on the deaths; and the accounts of them are perhaps more to be depended upon, as they appear to contradict the preconceived opinions of the person who collected them.

Speaking of the want of fruitfulness in the Swiss women, M. Muret says, that Prussia, Brandenburgh, Sweden, France, and indeed every country, the registers of which he had seen, give a greater proportions of baptisms to the number of inhabitants than the Pays de Vaud, where this proportion is only as 1 to 36. He adds, that from calculations lately made in the Lyonois, it appeared that in Lyons itself the proportion of baptisms was 1 in 28, in the small towns 1 in 25, and in the villages 1 in 23 or 24. What a prodigious difference, he exclaims, between the Lyonois and the Pays de Vaud, where the most favourable proportion, and that only in two small parishes of extraordinary fecundity, is not above 1 in 26, and in many parishes it is considerably less than 1 in 40. The same difference, he remarks, takes place in the mean life. In the Lyonois it is little

* *Mémoires, &c.* par la Société Economique de Berne, 1766, pp. 15, *et seq.*—*Essay on Population,* Vol. I. pp. 464, *et seq.* 5th edit.

above 25 years; while in the Pays de Vaud, the lowest mean life, and that only in a single marshy and unhealthy parish, is $29\frac{1}{2}$ years, and in many places it is above 45 years.

"But whence comes it (he says,) that the country where children escape the best from the dangers of infancy, and where the mean life, in whatever way the calculation is made, is higher than in any other, should be precisely that in which the fecundity is the smallest? How comes it again, that of all our parishes, the one which gives the mean life the highest, should also be the one where the tendency to increase is the smallest?" *

To resolve this question, M. Muret says, "I will hazard a conjecture, which, however, I give only as such. Is it not that, in order to maintain in all places a proper equilibrium of population, God has wisely ordered things in such a manner as that the force of life in each country should be in the inverse ratio of its fecundity? In fact, experience verifies my conjecture. Leyzin (a village in the Alps), with a population of 400 persons, produces but a little above eight children a-year. The Pays de Vaud, in general, in proportion to the same number of inhabitants, produces 11, and the Lyonois 16. But if it happen that at the age of 20 years, the 8, the 11, and the 16 are reduced to the same number, it will appear that the force of life gives in one place what fecundity does in another. And thus the most healthy countries, having less fecundity, will not over-people themselves, and the unhealthy countries, by their extraordinary fecundity, will be able to sustain their population."

These facts and observations are full of the most important instruction, and strikingly illustrate the principle of population. The three gradations in the proportion of births which are here so distinctly presented to our view, may be considered as representing that variety in the proportion of births which is known to take place in different countries, and at different periods; and the practical question is, Whether, when this variety prevails without a proportionate difference in the rate of increase, which is almost universally the case, we are to suppose, with M. Muret, that a special providence is called into action to render women less prolific in healthy countries, and where improved habits of cleanliness have banished plagues and mortal epidemics; or to suppose, as experience warrants, that the smaller mortality of healthy and improved countries is balanced by the greater prevalence of the prudential restraint on marriage and population.

The subject is seen with particular clearness in Switzerland, on account of the population of some of the districts being stationary. The number of inhabitants on the Alps was supposed to have diminished. This was probably an error; but it is not improbable that they should have remained stationary, or nearly so. There is no land so little capable of providing for an increasing population as mountainous pastures. When they have been once fully stocked with cattle, little more can be done; and if there be neither emigration to take off the superabundant numbers, nor manufactures wherewith to purchase an additional quantity of food, the deaths must equal the births.

This was the case with the Alpine parish of Leyzin before referred to, where, for a period of 30 years, the mortality and the proportion of births almost accurately kept pace with each other; and where, in consequence, if the positive checks to population had been unusually small, the preventive checks must have been unusually great. In the parish of Leyzin, according to M. Muret, the probability of life was as high as 61 years; † but it is obvious that this extraordinary degree of healthiness could not *possibly* have taken place under the actual circumstances of the parish with respect to the means of subsistence, if it had not been accompanied by a proportionate action of the prudential restraint on marriage; and accordingly the subsisting marriages, being late and unprolific, yielded only one birth to every twelve; the births were only 1 in 49, and the number of persons below 16 was only $\frac{1}{4}$ of the population.

There can be little doubt that in the present case the extreme healthiness of the people, arising from their situation and employments, had more effect in producing the prudential check to population, than the prudential check in producing the extreme healthiness; yet it is quite certain that they must constantly act and re-act upon each other, and that if, when the circumstances are such as to furnish no adequate means for the support of an increased population, and no relief in emigration, the prudential check does not prevail, no degree of natural healthiness could prevent an excessive mortality. Yet to occasion such a mortality, a much greater degree of poverty and misery must have taken place, than in districts less favourably circumstanced with regard to health; and we see at once the reason why, in countries of mountainous pasture, if there be no vent in emigration, the necessity of the prudential check should be more strongly forced on the attention of the inhabitants, and should, in consequence prevail to a greater degree.

Differences in the Registers of different Countries.

Taking countries in general, there will necessarily be differences as to natural healthiness in all the gradations, from the most marshy habitable situations to the most pure and salubrious air. These differences will be further increased by the nature of the employments of the people, their habits of cleanliness, and their care in preventing the spread of epidemics. If in no country was there any difficulty in obtaining the means of subsistence, these different degrees of healthiness would make a great difference in the progress of population; and as there are many countries naturally more healthy than the United States of America, we should have instances of a more rapid increase than that which has there taken place. But as the actual progress of population is, with very few exceptions, determined by the

* *Mémoires, &c. par la Société Econ. de Berne*, 1766, pp. 48, *et seq.*

† *Ibid.* Table V. p. 65 of the Tables.

relative difficulty of procuring the means of subsistence, and not by the relative natural powers of increase, it is found by experience that, except in extreme cases, the actual progress of population is little affected by unhealthiness or healthiness; but that these circumstances show themselves most powerfully in the character of the checks which keep the population down to the level of the means of subsistence, and occasion that sort of variety in the registers of different countries which was noticed in the instances mentioned by M. Muret.

Thus the population of two or three countries may be increasing at nearly the same rate, but one may be increasing chiefly from a great proportion of births, another from a small proportion of deaths, and a third from a more common proportion of both, in which three different cases the structure of the population and the registers of births, deaths, and marriages will be essentially different.

The rate at which the population of Sweden and Norway was increasing, at the time referred to by Mr Malthus, was not far from the same; but their registers differed in almost all points. While the births in Sweden were 1 in 28 of the population, the births in Norway were only 1 in 34; while the marriages in Sweden were 1 in 112, in Norway they were only 1 in 130; and while the mortality in Sweden was 1 in $34\frac{1}{2}$, in Norway it was only 1 in 48.* These different proportions of births, deaths, and marriages must essentially alter the whole structure of the population. The proportion of persons living at different ages, would be essentially different; the generations in one country would pass away sooner than the generations in the other; and Sweden might be said to increase principally from the large proportion of its births, and Norway, from the small proportion of its deaths, or its small mortality.

A large proportion of births, when they have room to expand themselves, is the most powerful element of increase, and is absolutely necessary in order to effect the shortest period of doubling with which we are acquainted; but two countries may have nearly the same proportion of births, and yet the population of one be quite stationary, while the population of the other is increasing with the greatest known rapidity. The proportion of births in the Dutch villages first noticed, approaches towards that of the United States of America; yet in the one case the population did not increase at all, and in the other it has increased so fast, as to be taken as a specimen of the natural progress of population when interrupted by the fewest checks to which human society is subject. In this case, though the proportions of births and marriages to the whole population might not be very unlike, and possibly no very great difference might appear in the proportion of marriages to births, the other points in the registers would be in the opposite extremes. While the mortality in the Dutch villages was as high as 1 in 22, it would probably be 1 in 41, or less, in the United States.—While the births and deaths in the Dutch villages were in the ratio of equality, in the United States they would be nearly in the proportion of 41 to 19.

In the same manner, two countries might have nearly the same mortality, and yet, in other points, be very different; and while one was increasing most rapidly, the other might be increasing very slowly. The proportion of deaths to the population in the Pays de Vaud, is not very essentially different from that of the United States, but the proportion of births, and the structure of the population present the most striking contrasts. The proportion of births for the whole of the Pays de Vaud was, according to M. Muret, 1 in 36, in many parishes it was considerably less than 1 in 40, and in one parish as low as 1 in 49; while, in the United States, it must be somewhere between 1 in 19 and 1 in 20.—The structure of the population was different accordingly. In the whole of the Pays de Vaud, the proportion of the population under 16 was one-third, in many parts and in the whole of the Canton of Berne one-fourth, while in the United States, it is as high as one-half.

Variations in the Age to which half of the Born live in different Countries.

We have seen, that, according to M. Muret, the probability of life, or the age to which half the born live, was, in the extraordinary parish of Leyzin, as high as 61 years. On the same authority, it appears that in nine other parishes of the Alps it was as high as 47; in 41 parishes of the Pays de Vaud and Jura 42; in 12 corn parishes 40; in 18 parishes among the great vineyards 37, in one marshy parish 24.† From other authorities we learn, that in country villages and parishes, the age to which half of the born live is such, that the major part will probably live to marry.‡ In the parish of Ackworth in Yorkshire, it appears from an exact account kept by Dr Lee of the ages at which all died there for 20 years, from 1747 to 1767, that half the inhabitants live to the age of 46 (Price, Vol. II. p. 35, 7th edit.); and if the same account had been kept in many of the other healthy parishes in England, where the yearly mortality, instead of being 1 in 47 as in Ackworth, was 1 in 60, 1 in 66, and even 1 in 75 (Vol. II. p. 224), half of the born would be found to have lived to above 50 or 55. In the whole of Sweden, where the annual mortality, at the time referred to by Dr Price, was greater than 1 in 35, it appears from his tables, that half of the born must have lived to above 33 (Vol. II. p. 413, 7th edit.); and in Great Britain generally, where the mortality at present, after making due allowance for the omissions in the deaths, appears to be less than 1 in 51, it cannot be doubted that there is scarcely a village in the country tolerably well situated, where half of the born do not live till above 40. In towns the case is very different. According to

* See Malthus *On Population*, Chapters i. and ii. of Book II.

† *Memoires, &c. par la Société Economique de Berne*, 1766, Table VIII. p. 92 of the Tables. As these calculations seem all to have been made from mortuary registers, they are all too low, except where the population was absolutely stationary.

‡ Graunt's and Short's *Observations, &c.* referred to by Dr Price, Vol. II. pp. 41, 42, &c. 7th edit.

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the data collected by Dr Price, one half of the born died in London under three years of age; in Vienna and Stockholm under two; in Manchester under five; in Northampton under ten (Vol. II. p. 33); and although in most of these towns, particularly those in England, a great improvement has taken place in their healthiness of late years, yet still they will always fall far short of the healthiness of country situations.

The age to which half the born live appears, therefore, to vary in different countries and places, and under different circumstances, in the very extraordinary degree of from 3 to 60. *

Variations in the Expectation of Life in different Countries.

The mean age of death, or the expectation of life, must necessarily be more steady; yet it appears to vary from about 16 or 17 to 50.

In Stockholm, according to a table calculated by Dr Price, from the medium of three different enumerations in 1757, 1760, and 1763, the expectation of life for males at birth was 14.25, and for females 18.10. † Taken together, the expectation of life was a little above 16. In Vienna, as appears from another table, it was $16\frac{1}{2}$. ‡ While, according to M. Muret, at Leyzin, the expectation of life at birth was, about the same period, 50 years. §

Variations in the Annual Mortality of different Countries.

The annual mortality, which is different, both from the age to which half of the born live, and the mean age of death, is found to vary in different places and countries, from about 1 in 19 to about 1 in 70. In Stockholm, the annual mortality was but 1 in 19 (Price's *Observations*, Vol. II. p. 136); and in some of the villages in England, even at the time that Dr Price wrote, it was as low as 1 in 70 and 1 in 75.

Proportion of the Births to the Population in different Countries.

The proportion of births to the population appears to vary in different countries and under different circumstances, from about 1 in 17 to 1 in 49. In New Spain, according to Humboldt, it was 1 in 17. In New Jersey, according to the rate of increase determined by the census taken in 1738 and seven years afterwards, the proportion of births must have been about 1 in 18. (Price, Vol. II. p. 50.) At present, as far as can be collected from scattered facts and inferences, the proportion of births in the whole of the United States is about 1 to 19. In the table for Prussia and Lithuania given by Sussmilch, it appears, that after the great plague of 1709 and 1710, and omitting the extraordinary year immediately subsequent, the proportion of births in the five years, ending with 1716, was 1 in less than 17. ‖ While, according to M. Muret, in the parish of Leyzin, the proportion of births was only 1 in 49 of the population.

Variations in the number of subsisting Marriages to one Annual Birth.

The number of subsisting marriages, which yields one annual birth, appears to vary from 12 to 4, and the two extreme cases occur in what may be called the same country, and are both noticed by M. Muret; the one in the parish of Leyzin, which presents all the symptoms of the prudential check to population in the greatest excess, and where twelve subsisting marriages yield only one annual birth; and the other in the parish of St Cergue in the Jura, where marriage is encouraged by the habit of emigration, and four subsisting marriages are sufficient to yield one annual birth.

Different Proportions of the Population under 16.

The proportion of the population under 16 years of age, to that above 16, seems to vary in different countries and places, and under different circumstances, from one-half to one-fourth. In the United States, it appears by the late census, that it is one-half; while in the canton of Berne it is not much more than one-fourth, and in the parish of Leyzin not more than one-fourth. ¶

Variations in the Mortality under 15.

The mortality under the age of 15 varies in different places and circumstances, from above two-thirds to one-fifth. It appears from a table of Dr Price, that in Stockholm, above two-thirds died under 15 (Vol. II. p. 418); while, according to M. Muret, the proportion of the deaths under the age of 15 was, in the whole of the Pays de Vaud, one-third, in many parishes of the Alps one-fourth, and the extraordinary parish of Leyzin only one-fifth. **

Under these very great variations in the registers of different countries and places, and in the structure of their population, it is obvious that we might fall into the grossest possible errors, by applying the registers of one country to the population of another. Even if we could find a country which was near to a just mean between these opposite extremes, and the registers of which were kept with the greatest accuracy, we could not apply such registers to any other country with a view to any important inferences; unless we knew that the two countries nearly resembled each other, not only in one or two particulars, but in all the main points relating to the structure of their population and the character of the prevailing checks to it.

First Tables of Mortality formed from the Registers of Towns, and on that account Erroneous.

When attention was first directed to tables of mortality, with a view to Assurances on lives and survivorships, these tables were almost universally formed from the registers of towns and of the neighbouring villages influenced by them. Buffon, calculating the probability of life from the registers of three parishes in Paris, and twelve country parishes in the neighbourhood, collected by M. Dupré de St Maur, makes it appear, that half of the born died under eight years of age. The parishes in Paris seemed to be healthier than the villages in the neighbourhood, which was occasioned by the custom of sending the

* This last number, stated by M. Muret for the parish of Leyzin on the Alps, is so very extraordinary, that possibly it may not be correct.

† *Observations on Reversionary Payments*, Vol. II. p. 421, 7th edit.

‡ *Id.* Vol. II. p. 128.

§ *Memoires, &c. par la Société Economique de Berne*, 1766, Table V. p. 65.

‖ *Gottliche Ordnung*, Vol. I. Table XXI. p. 83 of the Tables.—Malthus, Vol. II. p. 168. 5th edit.

¶ *Memoires, &c. par la Société Economique de Berne*, 1766, pp. 11 and 12.

** *Ibid.* Table XIII. p. 12.

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children from the city to be nursed in the country. Other calculations from the registers of Breslaw by Dr Halley, of London by Mr Simpson, and subsequently of Northampton, Warrington, Chester, Norwich, &c. by Dr Price and other writers, all concurred to convey the impression, that more than half of the born die under the age of puberty; and though Dr Price, in his two volumes of *Observations on Reversionary Payments,* takes frequent opportunities of dwelling upon the prodigious difference in the mortality of towns and of country situations, and produces abundance of evidence to show that, taken together, in the actual state of things, half of the born live much beyond the age of puberty; yet, among some persons who have not attended to the subject, the former impression seems still to have remained; and what is more strange, it has been lately asserted that this must happen from the constitution and course of human nature (Godwin's *Answer* to Malthus); which is going very much further than to say that it happens under the poverty, distress, and unhealthy occupations which are known to affect the mortality of a considerable body of people in all the nations with which we are acquainted.

The Constitution and Course of Human Nature only to be determined by Experience.

The constitution and course of human nature can only be determined by experience, and the analogies derived from it; and the kind of experience necessary to determine the point in question, is to be obtained only by a reference to registers which inform us of the ages at which the born have died. Now, from the evidence of registers of this kind which have been carefully kept in country parishes, it appears that the age to which half of the born live is much nearer to 40 than to the age of puberty. Even in Sweden, where the general mortality is unquestionably very great, owing to the poverty of the labouring classes, and the diseases brought upon them by bad and insufficient food during seasons of scarcity, the age to which half of the born live is, as before stated, above 33;* in the whole of the Pays de Vaud it is 41; in many particular parishes 47, in a parish in England not so healthy as many others 47; and as the expectation of life appears, by the late returns from the parish registers of Great Britain, to be as high as in Switzerland, there is little reason to doubt, from the evidence of registers, that the age to which half of the born live in this country can fall but little short of what it is in the Pays de Vaud;—that is, it must be somewhere near 40. But it will hardly be contended that there is no premature mortality in Great Britain occasioned by the pressure of poverty, and the effect of large towns and unwholesome occupations. Consequently, unless we are prepared to say that agricultural employments, airy and moderately sized towns, cleanliness, healthy occupations, and prudence, are against the constitution and course of nature, as applied to reasonable beings, we must acknowledge, that if the constitution and course of nature were carefully observed, and the admonitions which they give properly attended to, half of the born would, in healthy climates, live on an average to 45. Taking things, however, as they are, it is obvious that, according to the testimony of the best registers, more than half of the born might live to marry in most countries, even if the average age of marriage was so late as 30.

Immediate Causes of the Increase of Population.

The immediate cause of the increase of population is the excess of the births above the deaths; and the rate of increase, or the period of doubling, depends upon the proportion which the excess of the births above the deaths bears to the population.

The excess of births is occasioned by, and proportioned to, three causes; 1*st*, The prolifickness of the marriages. 2*dly*, The proportion of the born which lives to marry; and, 3*dly*, The earliness of these marriages compared with the expectation of life, or the shortness of a generation by marriage and birth, compared with the passing away of a generation by death.

In order that the full power of increase should be called into action, all these circumstances must be favourable. The marriages must be prolific, owing to their being contracted early; the proportion of the born living to marry must be great, owing both to the tendency to marriage, and the great proportion of births rising to the age of puberty; and the interval between the average age of marriage and the average age of death must be considerable, owing to the great healthiness of the country, and the expectation of life being high. Probably these three causes, each operating with the greatest known force, have never yet been found combined. Even in the United States, though the two first causes operate very powerfully, the expectation of life, and, consequently, the distance between the age of marriage and the average age of death is not so favourable as it might be. In general, however, the excess of births which each country can admit being very far short of the full power of increase, the causes above mentioned contribute to the required supply in very various proportions, according to the different circumstances and habits of each state.

Inferences to be drawn from Registers.

It would be very desirable to know something of these proportions with a view to their influence on the happiness of society. Our main sources of information on this subject are registers of births, deaths, and marriages; but in order to draw just inferences from them, we must consider well what they imply. The following observations and rules modified from Mr Malthus's chapter on the fruitfulness of marriages may be useful for this purpose.

Proportion of Births to a Marriage.

If we suppose a country where the population is stationary, where there are no emigrations, immigrations, or illegitimate children, and where the registers are accurate, then the proportion of the annual births to the annual marriages will accurately express both the number of children born to each marriage, including second and third marriages, and also the

* We allude to the registers and tables referred to by Dr Price. Since his time the health of the country has increased, like most of the countries in Europe, and the proportions of both the births and deaths have decidedly diminished.

proportion of the born which lives to marry once or oftener: while the annual mortality will accurately express the expectation of life.

But if the population be either increasing or decreasing, and the births, deaths, and marriages, increasing or decreasing in the same ratio, such a movement will necessarily disturb all the proportions; because the events which are contemporary in the registers are not contemporary in the order of nature.

In the first place, the births of any year cannot, in the order of nature, have come from the contemporary marriages, but must have been derived principally from the marriages of preceding years.

If we were to cut off a period of 30 years in the registers of any country some time ago, and inquire what was the number of births which had been produced by all the marriages included in the period cut off, it is evident, that, with the marriages at the beginning of the period will be arranged a number of births proceeding from marriages anterior to it; and at the end a number of births produced by the marriages included in the period, will be found arranged with the marriages of a succeeding period. Now, if we could subtract the former number, and add the latter, we should obtain exactly all the births produced by the marriages of the period, and thus ascertain the real prolifickness of marriages. If the population had been stationary, the number of births to be added would exactly equal the number to be subtracted, and the proportion of births to marriages, as found in the registers, would exactly represent the real prolifickness of marriages. But if the population be increasing, the number to be added would be greater than the number to be subtracted, and of course the proportion of births to marriages, as found in the registers, would always be too small to represent the true prolifickness of marriages. A contrary effect would take place in a decreasing population. The question, therefore, is, what we are to add, and what to subtract, when the births and deaths are not equal.

The average proportion of births to marriages in Europe, as taken from registers, is about 4 to 1. Let us suppose, for the sake of illustration, that each marriage yields four children, one every other year. In this case, wherever the period in the registers is begun, the marriages of the preceding eight years will only have produced half their births, and the other half will be arranged with the marriages within the period, and ought to be subtracted from them. In the same manner the marriages of the last eight years of the period will only have produced half their births, and the other half ought to be added. But half the births of any eight years may be considered as nearly equal to all the births of the succeeding $3\frac{3}{4}$ years. In instances of the most rapid increase it will rather exceed the births of the next $3\frac{1}{2}$ years, and in cases of slow increase, approach towards the births of the next 4 years. The mean, therefore, may be taken at $3\frac{3}{4}$ years. Consequently, if we subtract the births of the first $3\frac{3}{4}$ years, and add the births of the $3\frac{3}{4}$ years subsequent to the period, we shall have a number of births nearly equal to the number of births produced by all the marriages included in the period, and, of course, the prolifickness of marriages. But, if the population of a country be increasing regularly, and the births, deaths, and marriages continue always to bear the same proportion to each other, and to the whole population, it is evident that all the births of any period will bear the same proportion to all the births of any other period of the same extent, taken a certain number of years later, as the births of any single year to the births of a single year, taken the same number of years later. And, consequently, to estimate the prolifickness of marriages, we have only to compare the marriages of the present, or any other year, or the mean of five years, with the births of a subsequent year, or the mean of five years, taken $3\frac{3}{4}$ years later.

It has been supposed, in the present instance, that each marriage yields four births; but the proportion of births to marriages apparent in the registers of most of the countries of Europe, is 4 to 1, and, as the population of most of the countries of Europe is known to be increasing, the prolifickness of marriages must be greater than 4. If, allowing for this circumstance, we take the distance of 4 years instead of $3\frac{3}{4}$ years, we shall still be sure of not erring in excess. And though undoubtedly the period which we take, whatever it may be, will not answer exactly in different countries, yet its application generally will not be so incorrect as we might at first imagine; because, in countries where the marriages are more prolific, the births generally follow at shorter intervals, and where they are less prolific at longer intervals; and, with different degrees of prolifickness, the length of the period might still remain the same.

Probably, however, the period here assumed, which is the one taken by Mr Malthus, is too short. If, as he says, there is reason to think, that, in almost all registers, the omissions in the births and deaths are greater than in the marriages, there ought to be a greater number of births to each marriage, in which case it would take a longer time to have them in; and if, further, it is probable that a birth every other year is too rapid a succession for those countries where the marriages are frequently late, it may be thought that the births at the distance of five years will more nearly represent the prolifickness of marriages than at the distance of 4 years. But this matter must be left to the judgment of the reader.

At all events, it will follow, from what has been said, that the more rapid is the increase of population, the more will the real prolifickness of marriages exceed the proportion of births to marriages in the registers.

The rule which has here been laid down attempts to estimate the prolifickness of marriages, taken as they occur; but this prolifickness should be carefully distinguished from the prolifickness of first marriages, and of married women, and still more from the natural prolifickness of women in general, taken at the most favourable age. It is probable that the natural prolifickness of women is nearly the same in most parts of the world; but the prolifickness of marriages is liable to be affected by a variety of circumstances peculiar to each country, and particularly by the number of second and third, and late marriages. In all countries the second and third marriages alone form

Population. a most important consideration, and materially influence the average proportions. According to Sussmilch, in all Pomerania from 1748 to 1756, both included, the number of persons who married were 56,956, and of these 10,586 were widows and widowers (*Gottliche Ordnung*, Vol. I. Tables, p. 98). According to Busching, in Prussia and Silesia for the year 1781, out of 29,308 persons who married, 4841 were widows and widowers (Malthus, Vol. II. p. 140); and, consequently, the proportion of marriages will be given full one-sixth too much. In estimating the prolifickness of married women, the number of illegitimate births would tend, though in a slight degree, to counterbalance the overplus of marriages; and as it is found that the number of widowers who marry again is greater than the number of widows, the whole of the correction should not, on this account, be applied; but, in estimating the proportion of the born which lives to marry, which is what we are now about to proceed to, the whole of this correction is always necessary.

Proportion of the Born which lives to Marry.

To find the proportion of the born which lives to marry from registers, we must consider that the marriages of any year can never be contemporary with the births from which they have resulted, but must always be at such a distance from them, as is equal to the average age of marriage.

If the population be increasing, the marriages of the present year have resulted from a smaller number of births, than the births of the present year; and, of course, the marriages compared with the contemporary births, will always be too few to represent the proportion of the born which lives to marry, and the contrary will take place if the population be decreasing; and to find this proportion, after having first made the proper correction for second and third marriages, we must compare the marriages of any year with the births of a previous year at the distance of the average age of marriage.*

Expectation of Life.

The third principal object which it is desirable to attain, and of which some estimate may be formed from registers, is the expectation of life. It has before been stated, that, in a country where the births and deaths are equal, the rate of the annual mortality will express the expectation of life, or the average age of death. But, if the population be increasing, the actual population of any one year will be greater than would belong to the contemporary deaths, supposing the births equal to the deaths, and less than would belong to the contemporary births, supposing the deaths equal to the births. Consequently, if we divide the actual population by the number of contemporary deaths in an increasing country, the result will be too high to express the average age of death belonging to any given number of births. If we divide the actual population by the number of births, the result will be too low to express this average, or, in other words, to express the expectation of life. And, in order to approximate to the true proportion, we are directed by Dr Price (Vol. II. p. 39, 7th ed.), in the absence of better data, to divide the actual population by a mean between the proportions of deaths and births. Consequently, when we know the proportion of births to deaths in any country, and the proportions which they usually bear to the whole population, we may form some estimate of the expectation of life or the average age of death.

If we attend to these observations in drawing our inferences from registers, we shall generally be able to form an approximating estimate of the prolifickness of marriages, the proportion of the born living to marry, and the expectation of life, in different countries and places, and under different circumstances; or if we cannot do this satisfactorily, owing to the varying rate of increase, and the inaccuracy of the registers, we shall at least guard ourselves against drawing incorrect inferences from them in their present state, and reconcile many of the difficulties with which they appear to be accompanied.

Prolifickness of Marriages in England.

Thus to estimate the prolifickness of marriages in England. The proportion of the marriages to the births, according to the parochial returns ending with 1820, was 100 to 369; adding $\frac{1}{6}$ for the omissions in the births, or on the present occasion only $\frac{1}{7}$, in order to make full allowance for illegitimate births, the proportion of marriages to births will be as 100 to 422. These births, at the rate at which the population was increasing in England and Wales from 1810 to 1820, would, in about $4\frac{1}{2}$ years, increase .07, which, added to 4.22, makes 4.51. Consequently, the prolifickness of marriages, taken as they occur, and including second and third marriages, would be 4.51. If we wish to estimate the prolifickness of married women, we must subtract from the marriages those which consist of widows who have married again. According to some tables of Sussmilch, this would be little less than one-sixth; according to others one-eighth. If we take one-seventh, and deduct it from the marriages, the proportion will be 1 to 5.26, that is, each married woman will have 5.26 births. But of these married women, some have married at above 45 years of age, and many more above 35, so that there can be little doubt that, if the births could be collected from all the marriages in which the age of the woman did not exceed 35, nor the age of the man 45, the births would appear to be nearly six; and this number would be still further increased if the average age of marriage for males was 22, and for females 20. These conclusions are fully confirmed by some accurate observations of M. Muret. At Vevey, where the proportion of marriages to births, in the registers, was as 10 to 39, he found that 375 mothers had had 2093 children born alive, by which it appears that each mother had produced 5.55 births. But these, M. Muret observes, were all mothers, which is not the case of all married women. Allowing, however, for the usual proportion of barren wives at Vevey, which was about 20 out of 478, it appears that the married women, one with another, must have had above 5.3

* It is a shorter and more obvious process to compare the marriages at once with the births of the earlier period, than with the deaths, as Mr Malthus has done.

births. Yet this was in a town, where he intimates that the inhabitants do not enter into the marriage state at the time when nature calls them, nor when married always have as many children as they might have. It is evident, therefore, that the proportions of marriages to births, to be found in registers, require considerable and important corrections, in order to deduce from them just estimates of the prolifickness of marriages, the prolifickness of married women, and the prolifickness of women marrying at the most favourable age. The instance here given is sufficient to illustrate the mode in which the rule should be applied.

Proportion of the Born living to Marry in England.

If we wish to apply the rule for estimating the proportion of the born living to marry in England, we must first take the proportion of marriages to births in the registers. This proportion, as before stated, was, during the ten years ending with 1820, as 100 to 369; which, increased by one-sixth, the supposed omissions in the registers of births, will be as 100 to 430. But the marriages of the present year must have resulted, not from the births of the present year, but from the births at such an earlier period in the registers, as is equal to the average age of marriage. Suppose this age to be 28, then at the rate at which the population was increasing, the present marriages must have resulted from a number of births, equal to about two-thirds of the present number, so as to be to the present marriages in the proportion of 286 instead of 430 to 100. But of the 200 persons forming the 100 marriages, more than one-sixth have been married before. Deducting, therefore, one-sixth from the marriages, the proportion of the marriages to the births from which they have resulted, will be as 100 to 343; or out of 343 births, 200 have lived to be married once or oftener; from which it would appear, that on account of the late increase in the healthiness of the country, a greater proportion had lived to marry than when Mr Malthus last estimated it; which, together with a slight increase in the prolifickness of marriages apparent in the latter registers, may account for the more rapid increase of the population from 1810 to 1820. It should be recollected, however, that as the rate of increase which prevailed from 1810 to 1820 had by no means prevailed during the whole 28 years, the births, from which 200 persons had lived to marry in 1820, were decidedly more than 343.

It will be observed how very important the correction for second and third marriages is. Supposing each marriage to yield four births, and the births and deaths to be equal, it might at first be thought necessary, that in order to keep up the population, half of the born should live to marry; but if, on account of the second and third marriages, we subtract one-sixth from the marriages, and then compare them with the births, the proportion will be as 5 to 24; and it will appear, that instead of one-half, it will only be necessary that out of 24 births 10 should live to marry. Upon the same principle, if the births were to the marriages as 4 to 1, and exactly half of the born lived to marry, it might be supposed at first that the population would be stationary; but if we subtract one-sixth from the marriages, and then compare them with the births, it will be obvious that, on the supposition of half the born living to marry, the births at the earlier period in the registers, at the distance of the age of marriage, must be to the present births as 5 to 6, which would imply a moderate rate of increase.

To estimate the proportion of male births living to marry, we must subtract full one-fifth from the marriages; and according to this correction, if each marriage yielded four births, it would only be necessary that two male children out of five should live to marry, in order to keep up the population. It is necessary also, in estimating the proportion of male births living to marry, to make allowance for the greater number of males born.

The foregoing illustrations and remarks show the error of supposing that a country must be in a precarious state when the proportion of births to marriages in the registers is less than 4 to 1. If, indeed, this observation were just, the population of many countries in Europe would be in a precarious state, as in many countries the proportion is less than this. But it has been shown in what manner this proportion in the registers should be corrected, in order to make it a just representation of the prolifickness of marriages; and if a large part of the born live to marry, and the age of marriage be considerably earlier than the expectation of life, such a proportion in the registers is by no means inconsistent with a rapid increase of population.

In Russia, the proportion of births to marriages is less than 4 to 1. Yet on account of the large proportion of the born living to marry, the early age of marriage, and the high expectation of life, it is one of the countries in Europe which increases the fastest. In England, the population increases much more rapidly than in France; yet in England, the proportion of births to marriages in the registers, when allowance has been made for omissions, was, from 1800 to 1810, 4 to 1, while in France it was $4\frac{4}{5}$ to 1. (Malthus, Vol. II. p. 161, 5th edit.)

In England, indeed, for the ten years from 1810 to 1821, the proportion of births to marriages seems slightly to have exceeded the former proportion, being about 4.22 to 1; but this excess has been accompanied by such a rapidity of increase as would double the population in less than 46 years; and comparing this rapid rate of increase with the slow increase of France, where the births were to the marriages as $4\frac{4}{5}$ to 1, and in Sweden, when these proportions were as $4\frac{1}{4}$ to 1—it follows that the two other causes of the excess of births above the deaths, besides the prolifickness of marriages, must have very great power, and that the proportion of births to marriages, as found in registers, when taken alone, is a most uncertain criterion of increase.

Expectation of Life in England.

To apply the rule for estimating the average age of death, or the expectation of life in England, we must first ascertain from the registers the proportions which the births and deaths bear to the whole population. The annual average of the births for the ten years, from 1810 to 1821, was 325,506, of the deaths 200,999. Adding one-sixth to the births, and one-twelfth to the deaths, for the omission in the registers, the births will be 379,757, and the deaths 217,749. The population of England and

Population.

Wales, according to the last corrected accounts, was, in 1810, 10,502,500, in 1821, 12,218,500,* the mean of which in 11,360,500. The average births and deaths, compared with the mean population, give $\frac{1}{29.9}$ as the proportion of the births, and $\frac{1}{52.17}$ as the proportion of the deaths; and, according to Dr Price, the mean between them, which, in this case, is 41, will give the expectation of life. This rule, however, is only a rough approximation, and, in the few cases, where sufficient data have been obtained in progressive countries for calculating the expectation of life more accurately, it has turned out to be much nearer to the annual mortality than to the mean here referred to. While, according to the more correct estimates before adverted to, the annual mortality might, with the same expectation of life, be in different countries 1 in 39.38, 1 in 41.97, or 1 in 41.09, according as the population was stationary, or progressive at various rates.

This appears in the table which Dr Price himself calculated for Sweden (Vol. II. p. 410, 7th edit.), founded on data which he considered as quite satisfactory. It also appears in the table for Sweden and Finland, subsequently calculated by Mr Milne from similar data, in his *Treatise on Annuities and Assurances*. (Vol. II. p. 569.) And further, in a table for Sweden and Finland, published in this *Supplement*, under the head of MORTALITY. We have also lately seen a calculation by Mr Milne, by which it appears that the difference between the annual mortality and the expectation of life goes on increasing with the rate of the increase of the population to a certain point, but afterwards, owing to the increasing proportion of young children included in the population, diminishes; and is less when the population doubles in twenty-five years, than when it doubles in fifty years. Thus, on the three different suppositions of a stationary population, a population doubling in fifty years, and a population doubling in twenty-five years (all subjected to the same law of mortality as that which prevailed in Sweden and Finland during the five years ended with 1805)—in the first case, both the expectation of life and the annual mortality would be 39.388, and, of course, the expectation of life would be the same in all the cases; but in the second case, the annual mortality would be 1 in 41.971; and in the third, 1 in 41.096. It would be difficult, however, or at least premature, without further data, to lay down a general rule, with a view to determine correctly the expectation of life at birth, in countries progressive at various rates. But from what has been stated, it may safely be concluded, that the expectation of life lies very much nearer the annual mortality, particularly in cases of very rapid increase, than to the mean proposed by Dr Price; and that both the expectation of life, and the age to which half of the born live, are, in most countries, and especially in England, at the present time, considerably higher than they have generally been estimated.

It may be remarked here, in reference to England during the ten years, from 1810 to 1821, that the omissions assumed in the births and deaths do not give such proportions as to make the increase of population, from the excess of births above the deaths, answer to the increase determined by the two censuses,—an agreement which must necessarily take place if both the enumerations and the registers are accurate, and no external causes disturb the result. An addition of one-sixth to the births, and one-twelfth to the deaths, seemed to answer correctly for the interval from 1800 to 1810; but to produce the same coincidence under the more rapid increase of the subsequent ten years, either a greater allowance must be made for omissions in the births, or a less allowance for the omissions in the deaths. If we add one-fifth instead of one-sixth to the births, retaining one-twelfth for the deaths, the excess of births above deaths in the ten years will be 1,728,587; the excess according to the censuses being 1,716,000. If we add only one-thirtieth to the deaths, retaining one-sixth for the births, the excess will be 1,720,502, within 4502 of the excess, as shown by the censuses. Whereas, under the actual allowances which have been made for omissions, the excess will be only 1,620,800, leaving a difference of 95,200, and on the wrong side. On account of the almost incredible healthiness, considering our great towns and manufactories, which would be implied by supposing the deaths to be only deficient one-thirtieth, an increased omission in the births might be thought more probable; but it is believed, that since 1812 the omissions in the births have been diminished rather than increased; and under this uncertainty it has been thought better to leave the question as it stands at present, rather than attempt to determine it on insufficient data. It should always be remembered, however, that if the increase of population by the enumerations, is different from the increase of population by the registers, one or the other must be incorrect.

Expectation of Life at Birth and Annual Mortality, not the same when the Population is Progressive.

On the supposition that the omissions in the deaths were only one-thirtieth, the average mortality, compared with the average population, would be 1 in 54.7; and the proportion of births, with the addition of one-sixth, being, as before stated, 1 in 29.9, the expectation of life, according to Dr Price's rule, would be 42.3. On the other supposition, of an omission of one-fifth of the births, and one-twelfth in the deaths, the births would be 1 in 29, and the deaths 1 in 52.17, and the expectation of life would be 40.58.

It appears, then, that when the population of a country is progressive, it would be erroneous to estimate its healthiness by the proportion which the annual mortality bears to the whole population. Healthiness must be measured by the expectation of life; and if, with the same expectation of life, the annual mortality is affected by the rate of increase, it is obvious that the healthiness of different countries may be different, with the same rate of annual mortality.

* *Preliminary Observations to Population Abstracts*, p. 32.

Population.

Mortuary Registers fallacious.

But while it is evidently necessary that we should be cautious in inferring, that a country is healthy just in *proportion* to the smallness of its annual mortality, we should be still more cautious in inferring that it is unhealthy at all the ages under puberty, on account of the number which appear to die in mortuary registers under that age. Here, as in the preceding case, but in a much greater degree, the excess of the births above the deaths has a powerful effect, but exactly in the opposite direction. When we compare the annual mortality of an increasing country with its actual population, we compare with it a number of deaths which may be said, properly speaking, to belong to an earlier and smaller number of births, and must necessarily represent the country as more healthy than it really is. On the other hand, when in a mortuary register, we compare the deaths under puberty with those above, if the population be increasing, we evidently compare the deaths belonging to a much greater number of births than those which have furnished the deaths above the age of puberty; and, consequently, these proportions must represent the country as much less healthy than it really is.* According to the mortuary registers of Sweden for 21 years, from 1755 to 1776, more than half of the deaths were under 15, but it was by no means true that half of the *born* died under 15.† In the tables of mortality for Sweden during the same period, constructed by Dr Price, it appears that half of the born lived to above 33 years. ‡

In the same manner, in drawing inferences from an abstract of the mortuary registers of the principal cities in America, Baltimore, Boston, New York, and Philadelphia, given by Dr Seybert (*Statistical Annals*, p. 48), we must take care not to conclude that the proportions of the deaths which take place under 20 years of age, represent the proportions of any given number of births in these cities which die under 20. As, on account of the excess of the births above the deaths, all the early ages of the population are more numerous in proportion than the other, there will necessarily be a greater proportion of the deaths at these ages, than would naturally belong to a given number of births, if each infant born were traced to the age of its death.

In the present case, the abstract is only for a year, and no safe conclusions, therefore, can be drawn from it; but so far as it goes, as even notwithstanding the increase of population, these mortuary registers show that considerably less than half of the deaths take place under twenty (on an average only about 45½ *per cent.*), it would appear, that in the early ages of life, even the towns of America are more healthy than the whole of Sweden from 1755 to 1776. It should, however, be considered, that though the towns in America may be increasing fast by procreation, they are increasing still faster by the influx of inhabitants from the country; and as these inhabitants generally come to the towns after the age of sixteen, this accession diminishes the proportion of persons in the earlier ages of life so much, that there is probably a larger proportion of mortality at these ages in the country than in the towns.

Population.

Criterion of the Prevalence of Prudential Restraint.

One of the most interesting and useful points of view in which registers can be considered, is in the proofs which they afford of the varying prevalence of the prudential check to marriage and population in different countries and places. It has been not an uncommon opinion, and has even been strongly expressed of late years, although the subject has been much better understood than formerly, that the labouring classes of people, under the circumstances in which they are placed, cannot reasonably be expected to attend to prudential considerations in entering upon the marriage state. But that this opinion does them great injustice, is not only obvious to common observation, by which we can scarcely fail to see that numbers delay marriage beyond the period when the passions most strongly prompt to it, but is proved by the registers of different countries, which clearly show, either that a considerable number of persons of a marriageable age never marry, or that they marry comparatively late, and that their marriages are consequently less prolific than if they had married earlier. As the prudential restraint on marriage may show itself in either of these ways, it may prevail nearly in the same degree with a different proportion of marriages to the whole population. But on the supposition of the same natural prolifickness in the women of most countries, the smallness of the proportion of births will generally indicate with tolerable correctness the degree in which the prudential check to population prevails, whether arising principally from late, and consequently unprolific marriages, or from a large proportion of the population dying unmarried.

Referring then to the different proportions of births in different countries as the best criterion of the different degrees in which the prudential restraint on marriage operates, it will be recollected, that these proportions vary from about 1 in 36 to about 1 in 19, or even 17, in different countries, and in a much greater degree in different parishes or districts.

A particular parish in the Alps has already been mentioned, where the births were only a forty-ninth part of the population; and it appears by the late returns of the parish registers of England and Wales, that the births in the county of Monmouth are only 1 in 47, and in Brecon, 1 in 53; ‖ which, after making ample allowance for omissions, would show the prevalence of the prudential restraint on marriage in a high degree.

If in any country all were to marry at 20 or 21,

* In the first case, the effect is, in a considerable degree, counteracted by the large proportion of children under four years old, which a rapid increase occasions. In the second case, the effect has no such drawback.

† Price's *Observations*, Vol. II. p. 405. 7th edit.

‡ *Ibid.* Table XLV. Vol. II. p. 413.

‖ *Preliminary Observations*, p. 27.

Population. Effect of the Absence of Prudential restraint.

the proportion of the births would probably be more than 1 in 19; and this result would be still more certain if the resources of the country could not support an accelerated rate of increase, than if the means of subsistence were in the greatest abundance, and the demand for labour as effectual as it has ever been in the United States. On the latter supposition, taking the births at one-nineteenth, and the expectation of life the same as it is in England, the effect would be to occasion a most rapid increase of population; and the period of doubling, instead of being about 46 or 48 years, would be less than in America. On the other hand, if the resources of the country could not support a more rapid increase than that which has taken place in England and Wales during the ten years previous to the census of 1821, the effect would be a great diminution in the expectation of life. If the births were 1 in 19 instead of 1 in nearly 30, the same rate of increase would take place as at present, if the annual mortality were increased to about 1 in $26\frac{1}{2}$; and in that case, the expectation of life would be reduced in the proportion of from 41, or, as is more probable, from above 45 to less than 26.* This is the kind of effect which must inevitably follow the absence of the prudential check to marriage and population; and it cannot be doubted, that a considerable part of the premature mortality which is found to take place in all parts of the world is occasioned by it. The laws of nature, in application to man as a reasonable being, show no tendency to destroy half of the human race under the age of puberty. This is only done in very particular situations, or when the constant admonitions which these laws give to mankind are obstinately neglected.

Objection to the principle of Population arising from the great Mortality it must occasion.

It has been said, that a tendency in mankind to increase at such a rate as would double the population in 25 years, and, if it had full scope, would fill the habitable globe with people in a comparatively short period, cannot be the law of nature; as the very different rate of increase which is actually found to take place, must imply such an excessive degree of mortality and destruction of life as to be quite irreconcileable with actual facts and appearances. But the peculiar advantage of a law of increase in a geometrical progression is, that, though its power be absolutely immense, if it be left unchecked, yet, when this becomes impossible, it may be restrained by a comparatively moderate force. It can never, of course, happen, that any considerable part of that prodigious increase which might be produced by an uninterrupted geometrical progression should exist, and then be destroyed. The laws of nature which make food necessary to the life of man, as well as of plants and animals, prevent the continued existence of an excess which cannot be supported, and thus either discourage the production of such an excess, or destroy it in the bud, in such a way as to make it scarcely perceptible to a careless observer. It has been seen, that, in some countries of Europe, where the actual progress of the population is slower than in many others, as in Switzerland and Norway, for instance, the mortality is considerably less. Here, then, the necessity of a greater check to the natural progress of population produces no increase of mortality. And it appears, farther, that even the degree of mortality which in each year would be sufficient to destroy that excess of births which would naturally be produced if all married young, and all could be supported, might take place, and often does take place in particular situations, and yet is very little noticed. About the middle of last century, the mortality in Stockholm and London was about 1 in 19, and 1 in 20. This is a degree of mortality which would probably keep the births on a level with the deaths, even though all married at twenty. And yet numbers resorted both to Stockholm and London from choice; the greater part probably not aware that, by so doing, they would shorten their own lives and those of their children; and the rest thinking that the difference was not worth attending to, or was at least balanced by the advantages of society and employment which the town presented. There is nothing, therefore, in the actual state of the mortality observed to take place in different countries and situations, which, in the slightest degree, contradicts the supposition of a natural tendency to increase quite as great as that which has been stated.

Objection that mere Tendencies are not to be considered.

It has been further remarked, that as, in point of fact, it very rarely happens that mankind continue to increase in a geometrical progression of any kind, and only in a single instance in such a one as to double the population in 25 years, it is useless and absurd to lay any stress upon *tendencies* which never for any length of time together produce their natural effects. But it might really as well be said, that we are not to estimate the natural rate of increase in wheat or sheep; as it is quite certain that their natural tendency to increase has never practically continued to develope itself for so long a time together, as that of mankind. Both as a physical, and even economical question, it is curious and desirable to know the natural law of increase which prevails among the most important plants and animals. In the same view, it must be still more interesting to know the natural law of increase with respect to man. It may be said indeed, with truth, that the actual appearances all around us,—the varying rate of increase in different countries,—its very slow progress, or stationary state, in some, and its very rapid progress in others,—must be a mass of anomalies, and quite contrary to the analogies of all the rest of animated nature; if the natural tendency of mankind to increase be not, at the least, as great as that which is developed under the most favourable circum-

* If, as it has appeared, the expectation of life, though by no means the same, does not differ very much from the annual mortality, and the annual mortality in this country during the ten years from 1810 to 1820, after every abatement, appears to be not more than 1 in 51, the expectation of life cannot be less than 45, and is probably greater.

stances, while in all others it is kept down by the varying difficulties which the state of the soil, and other obstacles oppose to it. But the question, as it applies to man, assumes at once a tenfold importance, in reference to the moral and political effects which must result from those checks to increase, the existence and operation of which, in some form or other, no human exertions can by possibility prevent. A field is here opened for the most interesting inquiries which can engage the friends of human happiness.

But, as a preliminary to these inquiries, it is obvious that we must know the degree of force to be overcome, and the varying character of the checks which, in the different countries of the world, are practically found to overcome it; and, for this purpose, the first step must be an endeavour to ascertain the natural law of population, or the rate at which mankind would increase under the fewest known obstacles. Nor can this tendency to increase ever safely be lost sight of in the subsequent inquiries, which have for their object the improvement of the moral condition of man in society.

Right of the Poor to full Support considered.

The existence of a tendency in mankind to increase, if unchecked, beyond the possibility of an adequate supply of food in a limited territory, must at once determine the question as to the natural right of the poor to full support in a state of society where the law of property is recognized. The question, therefore, resolves itself chiefly into a question relating to the necessity of those laws which establish and protect private property. It has been usual to consider the right of the strongest as the law of nature among mankind as well as among brutes; yet, in so doing, we at once give up the peculiar and distinctive superiority of man as a reasonable being, and class him with the beasts of the field. In the same language it may be said that the cultivation of the earth is not natural to man. It certainly is not to man, considered merely as an animal without reason. But to a reasonable being, able to look forward to consequences, the laws of nature dictate the cultivation of the earth, both as the means of affording better support to the individual, and of increasing the supplies required for increasing numbers; the dictates of those laws of nature being thus evidently calculated to promote the general good, and increase the mass of human happiness. It is precisely in the same way, and in order to attain the same object, that the laws of nature dictate to man the establishment of property and the absolute necessity of some power in the society capable of protecting it. So strongly have the laws of nature spoken this language to mankind, and so fully has the force of it been felt, that nothing seems to be thought so absolutely intolerable to reasonable beings as the prevalence in the same society of the right of the strongest; and the history of all ages shows that if men see no other way of putting an end to it, than by establishing arbitrary power in an individual, there is scarcely any degree of tyranny, oppression, and cruelty which they will not submit to from some single person and his satellites, rather than be at the mercy of the first stronger man who may wish to possess himself of the fruit of their labour. The consequence of this universal and deeply-seated feeling, inevitably produced by the laws of nature, as applied to reasonable beings, is that the almost certain consequence of anarchy is despotism.

Allowing, then, distinctly, that the right of property is the creature of positive law, yet this law is so early and so imperiously forced on the attention of mankind, that if it cannot be called a natural law, it must be considered as the most natural as well as the most necessary of all positive laws; and the foundation of this pre-eminence is, its obvious tendency to promote the general good, and the obvious tendency of the absence of it to degrade mankind to the rank of brutes.

As property is the result of positive law, and the ground on which the law which establishes it rests, is the promotion of the public good and the increase of human happiness, it follows, that it may be modified by the same authority by which it was enacted, with a view to the more complete attainment of the objects which it has in view. It may be said, indeed, that every tax for the use of the government, and every country or parish rate is a modification of this kind. But there is no modification of the law of property having still for its object the increase of human happiness, which must not be defeated by the concession of a right of full support to all that might be born. It may be safely said, therefore, that the concession of such a right, and a right of property are absolutely incompatible, and cannot exist together.

To what extent assistance may be given even by law to the poorer classes of society when in distress, without defeating the great object of the law of property, is essentially a different question. It depends mainly upon the feelings and habits of the labouring classes of society, and can only be determined by experience. If it be generally considered as so discreditable to receive parochial relief, that great exertions are made to avoid it, and few or none marry with a certain prospect of being obliged to have recourse to it, there is no doubt that those who were really in distress might be adequately assisted, with little danger of a constantly increasing proportion of paupers; and in that case a great good would be attained without any proportionate evil to counterbalance it. But if, from the numbers of the dependent poor, the discredit of receiving relief is so diminished as to be practically disregarded, so that many marry with the almost certain prospect of becoming paupers, and the proportion of their numbers to the whole population is in consequence continually increasing; it is certain that the partial good attained must be much more than counterbalanced by the general deterioration in the condition of the great mass of the society, and the prospect of its daily growing worse: so that, though from the inadequate relief which is in many cases granted, the manner in which it is conceded, and other counteracting causes, the operation of poor-laws such as they exist in England might be very different from the effects of a full concession of the right, and a complete fulfilment of the duties resulting from it; yet such a state of things ought to give the most serious alarm to every friend to the happiness of society, and every effort consistent with justice and humanity ought to be made to remedy it.

But whatever steps may be taken on this subject, it will be allowed, that with any prospect of legislating for the poor with success, it is necessary to be fully aware of the natural tendency of the labouring classes of society to increase beyond the demand for their labour, or the means of their adequate support, and the effect of this tendency to throw the greatest difficulties in the way of permanently improving their condition.

It would lead far beyond the limits which must be prescribed to this article, to notice all the various objections which have been made by different writers to the principles which have been here explained. Those which contain in them the slightest degree of plausibility have been answered by Mr Malthus in various parts of the late editions of his work, and particularly in the appendix to the fifth edition, to which we refer the reader. We will only, therefore, further notice the objection which has been made by some persons on religious grounds; for, as it is certainly of great importance that the answer which has been given to it should be kept in mind, we cannot refuse a place to a condensed statement of it at the end of this article.

Religious Objection considered.

It has been thought that a tendency in mankind to increase, beyond the greatest possible increase of food which could be produced in a limited space, impeaches the goodness of the Deity, and is inconsistent with the letter and spirit of the Scriptures. If this objection were well founded, it would certainly be the most serious one which has been brought forwards; but the answer to it appears to be quite satisfactory, and it may be compressed into a very small compass.

First, It appears that the evils arising from the principle of population are exactly of the same kind as the evils arising from the excessive or irregular gratification of the human passions in general, and may equally be avoided by moral restraint. Consequently there can be no more reason to conclude, from the existence of these evils, that the principle of increase is too strong, than to conclude, from the existence of the vices arising from the human passions, that these passions are all too strong, and require diminution or extinction, instead of regulation and direction.

Secondly, It is almost universally acknowledged, that both the letter and spirit of revelation represent this world as a state of moral discipline and probation. But a state of moral discipline and probation cannot be a state of unmixed happiness, as it necessarily implies difficulties to be overcome, and temptations to be resisted. Now, in the whole range of the laws of nature, not one can be pointed out which so especially accords with this scriptural view of the state of man on earth; as it gives rise to a greater variety of situations and exertions than any other, and marks, in a more general and stronger manner, and nationally, as well as individually, the different effects of virtue and vice, of the proper government of the passions, and the culpable indulgence of them. It follows, then, that the principle of population, instead of being inconsistent with Revelation, must be considered as affording strong additional proofs of its truth.

Lastly, It will be acknowledged, that in a state of probation, those laws seem best to accord with the views of a benevolent Creator, which, while they furnish the difficulties and temptations which form the essence of such a state, are of such a nature as to reward those who overcome them with happiness in this life as well as in the next. But the law of population answers particularly to this description. Each individual has the power of avoiding the evil consequences to himself and society resulting from it, by the practice of a virtue dictated to him by the light of nature, and sanctioned by revealed religion. And, as there can be no question that this virtue tends greatly to improve the condition, and increase the comforts both of the individuals who practise it, and through them of the whole society, the ways of God to man with regard to this great law are completely vindicated.

Subjoined are two Tables which may assist the reader in calculating the rate of increase in different countries, under different circumstances, and from different data. The first is the table calculated by Euler, and printed in Mr Malthus's work, at the end of his chapter on the *Fruitfulness of Marriage;* and the second has been calculated by Mr Bridge of Cambridge, well known as an able mathematician, and most useful elementary writer.

The first is to be used when it is wished to estimate the rate of increase by the proportions of the births to the deaths, and of these to the whole population. The yearly increase of people, independently of immigration, is the yearly excess of the births above the deaths, and the yearly rate of increase is measured by the proportion which this excess bears to the whole population. The fraction expressing the deaths must therefore be subtracted from the fraction expressing the births; and the remainder will be the fraction expressing the yearly rate of increase; opposite to which will be found the number of years in which the population will double itself, supposing the yearly rate of increase to continue the same for a sufficient length of time.

The second table is to be used when it is wished to know the period of doubling, resulting from a given *per centage* increase in ten years, determined by enumeration. An estimate of population from births and deaths is always liable to much uncertainty on account of the varying proportions which they bear to the population. The only remedy for this uncertainty is a census; and as the useful custom of taking a census of the population every ten years has latterly prevailed in some countries, the second table is constructed to show the period of doubling, or general rate of increase, which results from any given *per centage* increase in ten years. The first column represents the *per centage* increase in ten years determined by two enumerations; and the second column the number of years in which the population will double itself, supposing it to proceed at the same rate. (O. O. O.)

Population.

TABLE I.

The Proportion of the Excess of Births above the Deaths, to the whole of the Living.	Periods of Doubling in Years and Ten Thousandth Parts.	The Proportion of the Excess of Births above the Deaths, to the whole of the Living.	Periods of Doubling in Years and Ten Thousandth Parts.
10	7.2722	110	76.5923
11	7.9659	120	83.5230
12	8 6595	130	90.4554
13	9.3530	140	97.3868
14	10.0465	1 : 150	104.3183
1 : 15	10.7400	160	111.2598
16	11.4333	170	118.1813
17	12.1266	180	125.1128
18	12.8200	190	132 0443
19	13.5133	200	138.9757
20	14.2066		
21	14.9000	210	145.9072
22	15.5932	220	152.8387
23	16.2864	230	159.7702
24	16.9797	240	166.7017
1 : 25	17.6729	1 : 250	173.6332
26	18.3662	260	180.5647
27	19.0594	270	187.4961
28	19.7527	280	194.4275
29	20.4458	290	201.3590
30	21.1391	300	208.2905
32	22.5255	310	215.2220
34	23.9119	320	222.1535
36	25.2983	330	229.0850
38	26.6847	340	236.0164
1 : 40	28.0711	1 : 350	242.9479
42	29.4574	360	249.8794
44	30.8438	370	256.8109
46	32.2302	380	263.7425
48	43.6161	390	270.6740
50	35.0029	400	277.6055
55	38.4687	410	284.5370
60	41.9345	420	291.4685
65	45.4003	430	298.4000
70	48.8661	440	305.3314
1 : 75	52.3318	1 : 450	312.2629
80	55.7977	460	319.1943
85	59.2634	470	326.1258
90	62.7292	480	333.0573
95	66.1950	490	339.9888
100	69.6607	500	346.9202
		1 : 1000	693.49.

TABLE II.

Per Centage Increase in Ten Years.	Period of Doubling.	*Per Centage* Increase in Ten Years.	Period of Doubling.
	Years.		Years.
1.	696.60	23.5	32.83
1.5	465.55	24.	32.22
2.	350.02	24.5	31.63
2.5	280.70	25.	31.06
3.	234.49	25.5	30.51
3.5	201.48	26.	29.99
4.	176.73	26.5	29.48
4.5	157.47	27.	28.99
5.	142.06	27.5	28.53
5.5	129.46	28.	28.07
6.	118.95	28.5	27.65
6.5	110.06	29.	27.22
7.	102.44	29.5	26.81
7.5	95.84	30.	26.41
8.	90.06	30.5	26.03
8.5	84.96	31.	25.67
9.	80.43	31.5	25.31
9.5	76.37	32.	24.96
10.	72.72	32.5	24.63
10.5	69.42	33.	24.30
11.	66.41	33.5	23.99
11.5	63.67	34.	23.68
12.	61.12	34.5	23.38
12.5	58.06	35.	23.09
13.	56.71	35.5	22.81
13.5	54.73	36.	22.54
14.	52.90	36.5	22.27
14.5	51.19	37.	22.01
15.	49.59	37.5	21.76
15.5	48.10	38.	21.52
16.	46.70	38.5	21.28
16.5	45.38	39.	21.04
17.	44.14	39.5	20.82
17.5	42.98	40.	20.61
18.	41.87	41.	20.17
18.5	40.83	42.	19.76
19.	39.84	43.	19.37
19.5	38.91	44.	19.00
20.	38.01	45.	18.65
20.5	37.17	46.	18.31
21.	36.36	47.	17.99
21.5	35.59	48.	17.68
22.	34.85	49.	17.38
22.5	34.15	50.	17.06
23.	33.48		

Porson.

PORSON (Richard), the greatest of the verbal critics and classical scholars of modern times, born 25th December 1759, was the son of Mr Huggin Porson, parish clerk of East Ruston, near North Walsham, in Norfolk.

His father taught him, in his childhood, to practise all the common rules of arithmetic by memory only; and, before he was nine years old, he had learned to extract the cube root in this manner. He employed, at the same time, for teaching him to read and write, the method which has since been generally introduced in the schools of mutual instruction, making him draw the letters with chalk or on sand: and the neatness and accuracy of his handwriting, for which he was distinguished through life, may be considered as bearing ample testimony to his father's ingenuity and success.

At the age of nine he was sent to a village school, kept by a Mr Summers; but his father still made him repeat by heart in the evening the whole of the lessons of the day, and there seems to be sufficient evidence for considering this practice of exercising the memory continually, in very early life, as the best, if not the only method of cultivating, if not of producing great talent: for though a strong memory by no means constitutes talent, yet its possession is almost a necessary condition for the successful exertion of talent in general, and, indeed, it is very possible that the other faculties of the mind may be strengthened by the early cultivation of this one. It is remarkable that Wallis, who was as deservedly celebrated in his day as Porson, for his unerring sagacity, had also a singular facility of retaining numbers and calculations in his memory, but without having taken any particular pains to acquire the habit. Mr Hewitt, the vicar of the parish of East Ruston, hearing of young Porson's uncommon capacity, undertook to instruct both him and his brother Thomas in classical literature; and when he was about fifteen, Mr Norris, a wealthy and respectable gentleman of the neighbourhood, having ascertained the truth of the reports that he heard of him, resolved to be at the expense of sending him to Eton. Without this assistance, it would have been impossible for Porson to have acquired great excellence in any intellectual pursuit; for his father's situation in life was not such as to exempt his son even from the subordinate occupations of the country. He went out gleaning, in the autumn, with a Horace in his pocket; and he had learned by experience to appreciate the mechanical labours of Penelope, before he was much acquainted with the wisdom and wanderings of Ulysses.

At Eton, his talents procured him the friendship and admiration of the seniors among his schoolfellows, and, upon the unfortunate death of his first patron, Mr Norris, he found a number of liberal contributors, who stepped forward to supply the deficiency; but by far the most active of them was Sir George Baker, then President of the Royal College of Physicians; a man as much distinguished by his own classical taste and acquirements, as by his laudable disposition to cherish learning in others. He received the boy into his house for a vacation, and undertook, at the request of a relation of Mr Norris, the disagreeable task of receiving, in small sums, as much as was sufficient to purchase an income of L. 80 a year, for a few years, in the short annuities, which served, with great economy, to enable him to remain at Eton. This favour appears to have been too great to be properly acknowledged, or perhaps even duly appreciated, by its object, who only after many years paid Sir George the tardy compliment of a dedication, not, however, of an edition, but of a handsome copy of a single play of Euripides. In his own opinion, Porson learned little at Eton besides the quantity of syllables, being able to repeat by heart before he went there the principal part of the authors that he had to read; that is, almost the whole of Horace and Virgil, and the *Iliad*, and many parts of Cicero, Livy, and the *Odyssey*. A story is accordingly told of his book having been changed by one of his schoolfellows in joke, when he was going up to a lesson in Horace, and of his having read and translated what was required of him, without at all betraying the change to the master. At the same time, the emulation of a public school must have been a great advantage to him, as affording him a motive for exertion in his exercises, whether they were to be called his own, or to be written for other boys. It was a copy of Toup's Longinus, presented to him as a reward for a good exercise, that first gave him a decided inclination for the pursuit of critical researches; but he always considered Bentley and Dawes as his great masters in criticism.

In 1777 he was sent to Trinity College, Cambridge, and at first he began to apply more particularly to the mathematics, which had been the favourite study of his boyhood, and in which, as he himself remarked, his proficiency first brought him into a certain degree of public notice. He was, however, soon diverted from the pursuit, although he attained a place among the *senior optimes* of his year. But he was in fact more calculated for classical than for mathematical excellence; his memory would have been in a great measure thrown away, if he had been employed in abstract calculations; and his inventive powers do not appear to have been at all of the same class with his retentive faculties; although certainly in the mechanical pursuit of the fashionable methods of modern analysis, which are intended, like steam engines, to overcome all difficulties by the inanimate forces of mere patience and perseverance, he was capable of filling as distinguished a place as any living algebraist. The classical prize medal, and the university scholarship, he obtained without difficulty, as matters of course. The exercise, which he exhibited upon the examination for the scholarship, is the well known translation of an epitaph into Greek iambics; which, although not free from some inaccuracies in the use of the tenses, is still a very remarkable production, when it is considered as having been completed in less than an hour, with the help of Morell's *Thesaurus* only, and never afterwards corrected.

He obtained a fellowship of Trinity College in 1781, and took his degree of Master of Arts in 1785; but not thinking it right to subscribe the Articles of the Church of England, he could not enter into orders, and he was therefore unavoidably de-

prived of his fellowship in 1791, having no dependence left for his subsistence through life, but his abilities and acquirements. His friends, however, did not abandon him on this urgent occasion, and in order to keep him out of actual want, a private subscription was set on foot, to which Mr Cracherode was one of the principal contributors, and by which enough was raised to purchase him an annuity of about L. 100 a year for life. A small addition was made to his income, about two years after, by his election to the Greek Professorship at Cambridge, with a salary of only L. 40 a year. The situation, however, gave him the option of at least doubling his whole receipts, by the delivery of an annual course of lectures in the university; and it was supposed that he would have made this exertion, if he had not been discouraged by the difficulty of obtaining rooms in his college, where it would have been his wish to reside.

He married, in 1795, Mrs Lunan, a sister of the late Mr Perry, well known as the editor of the *Morning Chronicle,* but he had the misfortune to lose his wife two years afterwards. Mr Perry continued to be his greatest friend through life, and was so far his best benefactor, as he knew how to oblige him essentially, without the appearance of doing him a favour. Porson had sometimes chambers in the Temple, and sometimes he lodged at the *Morning Chronicle* office: frequently also he was a visitor at Mr Perry's house at Merton, where he had the misfortune to leave several of his books, at the time of a fire, which destroyed them all, and among them some letters of Rhunkenius, with whom he had begun a correspondence in 1783, and who had communicated to him some valuable fragments of Æschylus, besides his manuscript copy of the lexicon of Photius, which had cost him ten months labour. He used indeed to say that this fire had destroyed the fruits of twenty years of his life; but he had the resolution to complete a second copy of the Photius, which is now in the library of Trinity College. His fondness for the mechanical employment of his pen has been regretted by some of his biographers, as having tempted him to waste much of his most valuable time on a trifling amusement: but in fact, his mode of writing Greek was fully as much calculated for expedition as for beauty; and those, who have not been in the habit of correcting mutilated passages of manuscripts, can form no estimate of the immense advantage that is obtained, by the complete sifting of every letter, which the mind involuntarily performs, while the hand is occupied in tracing it: so that, if the correction of Photius was really worth the labour of two years of Porson's life, it would have been scarcely possible to employ the greater part of those years more advantageously, than by copying him twice over. Mr Weston, in speaking of "his matchless penmanship," has observed, not very intelligibly, that "here, indeed, he thought himself surpassed by" another person "not in the stroke, but the sweep, of his letters:" what Porson really said on this subject was, that, with respect to "command of hand," that person had the advantage, but he preferred the *model* on which his own hand was formed. His writing was, in fact, more like that of a scholar, while the method explained in Mr Hodgkin's *Calligraphia* exhibits more the appearance of the work of a writing master; holding, however, a middle place between the neatness of Porson, and the wonderful accuracy of the country schoolmaster who made the fac simile of the Oxford Pindar in the British Museum.

Upon the establishment of the London Institution, his friends obtained for him the very desirable appointment of principal librarian, with a salary of L. 200 a year, and apartments in the house of the Institution, which was then in the Old Jewry; but although the arrangement was highly honourable to all parties, the librarianship was little more than a sinecure. Porson was, however, in the habit of attending in his place when the reading room was open, and of communicating, very readily, all the literary information that was required, by those who consulted him respecting the object of their researches. Had the inhabitants of Finsbury Square and its neighbourhood been more disposed to classical studies, and had the librarian of the Institution survived, to witness its completion and prosperity, his sphere of utility would, without doubt, have been greatly extended.

But it must ever be lamented that Porson's habits of life had unfortunately been such as to lay a foundation for a multitude of diseases; he suffered much from asthma throughout the year 1808; his memory began to fail him a little; and in the autumn he had some symptoms of intermittent fever. On Monday the 19th of September he had an apoplectic attack in the street, and he was carried to a neighbouring poor house in a state of insensibility: the next day an advertisement appeared in one of the papers, relating the accident, and describing some manuscripts which were found in his pocket, consisting of Greek fragments and algebraical characters: his friends at the London Institution immediately went in quest of him: he was afterwards well enough to appear in the library, and to receive a visit there from Dr Adam Clarke: but his speech was impaired, and his faculties evidently imperfect; he survived only through the week, and died in his 49th year, on Sunday the 25th of September 1808, at midnight.

He was buried at Cambridge, in Trinity College Chapel, near the grave of Bentley, and the monument of Newton. He founded by will an annual prize, to be given to the best Greek translation from an English dramatic author: and several specimens of the successful pieces have been published from time to time in the *Classical Journal.* His books were sold by auction, and many of them found purchasers at high prices, especially such as were enriched with any of his manuscript notes in their margins; but more than two hundred of these, which appeared to be the most valuable, were withheld from the sale, and were afterwards purchased, together with the whole of his manuscript papers, by the Society of Trinity College. for the sum of a thousand guineas. He left a sister, married to Siday Hawes, Esq. of Coltishall, Norfolk. His brother Thomas kept a boarding-school at Fakenham, and died, without issue, in 1792: his

second brother Henry was a farmer in Essex, and died young, leaving three children. His father had lived to 74, his mother to 57.

The principal works of Porson are his *Letters to Travis*, his four plays of Euripides with their prefaces, and the manuscript copy of Photius: the rest, though somewhat voluminous, are chiefly miscellaneous annotations on detached passages of a multitude of ancient authors. We find nothing in the nature of theory, or of the discovery of general laws, except some canons, which he has laid down, chiefly as having been used by the Greek tragedians in the construction of their verses. These are chiefly contained in the preface to the *Heuba*, together with its supplement. 1. The first is, that when a tragic iambic ends with a trisyllable, or a cretic, this word must be preceded either by a short syllable, or by a monosyllable. For example, an ancient tragedian would not have written the line Ἔχοι δὲ μήποτ᾽ ἐξ ἀπευκτοῦ σώματος; though it might have been unexceptionable in a comedy. It seems to have been about the year 1790 that Porson first made this observation; he certainly did not attend to it in his own serious translation of the *Epitaph on Alexis:* but it was mentioned, in 1791, by one of Porson's intimate friends, in a moment of conviviality, while he was somewhat characteristically attempting to fill his glass out of an empty bottle; and the author of this article observed in answer, that it would certainly sound better, on such an occasion as then occurred, to say, Πᾶν ἐκπέπωκας· οὐδ᾽ ἔνεσΤΙ κότταβος, than οὐ λέλειπΤΑΙ κότταβος. 2. The second canon is, that an anapaest is only admissible in a tragic iambic, as constituting the first foot, except in some cases of proper names: this indeed had been cursorily hinted by Dawes. 3. The same critic had also remarked, that the Attic poets never lengthen a short vowel before a mute or aspirate, followed by a liquid, or a middle consonant followed by ρ; and Porson more amply confirmed the observation as very generally, though not universally correct. On the other hand, Dawes had cursorily observed that Homer, and the other ancient epic poets, generally lengthened the vowel in such cases, and Porson's great rival, Hermann, has more fully established this distinction, as affording a good criterion of antiquity. 4. There are also some original remarks of Porson on the caesura, in iambics, and trochaics, and anapaests: he showed that the scenic poets do not elide the final iota, and that the tragedians do not employ the preposition περὶ before a vowel; and some other general laws, of greater importance than these, may probably be found in some of his publications, which it will now be necessary to enumerate in the order of time.

1. His first attempts, as an author, consisted of some anonymous articles in Dr Maty's *Review*, beginning with a part of Schutz's *Æschylus*, June 1783, *Tracts* ii. Brunck's *Aristophanes*, July 1783, *Tracts* iii.; *Mus. Crit.* II. 113; written in a day. In Latin, by Schäfer, *Class. Journ.* V. 136. Weston's *Hermesianax*, April 1784, *Tracts* iv. Huntingford's *Apology for his Menostrophics*, August 1784, *Tracts* v. *Account of the Learned Pig*, April 1785, *Tracts* vi. *Note*, with letters of Le Clerc and Bentley, April 1786, *Tracts* vii.

2. He added some *Notes* to an edition of Xenophon's *Anabasis*, published by Nicholson, at Cambridge. 4to and 8vo. 1786. They are addressed *Lecttori si quis erit.*

3. *Three Panegyrical Epistles to Sir John Hawkins, Gent. Mag.* Aug. Sept. Oct. 1787. *Tracts* ix.

4. *Notes on Toupii Emendationes in Suidam.* 8vo. Oxf. 1790. Written in 1787.

5. *Letters on the Three Witnesses, Gent. Mag.* Oct. Dec. 1788. Feb. April, May, June, Aug. 1789. Feb. 1790. The last reprinted, *Tracts* xix.; most of the others in the collection of *Letters to Mr Archdeacon Travis*, in answer to his defence of the *Three Heavenly Witnesses*, 8vo. Lond. 1790. These letters are generally considered, by critics of all parties, as finally decisive of a question, which had often been agitated before, but never so learnedly argued, nor so satisfactorily discussed in all its bearings.

6. In the *Monthly Review*, Robertson's *Essay on the Parian Chronicle*, Jan. 1789, *Tracts* xiii.; satisfactorily answering the principal part of the objections alleged against the authenticity of that monument. Edwards's edition of the work attributed to Plutarch, *on Education*, July 1793, *Tracts* xxi. Payne Knight's *Greek Alphabet*, Jan. 1794, *Tracts* xxiii. Pybus's *Sovereign*, Dec. 1800; an article affording a good specimen of his talent for humour.

7. He is supposed to have written some *Remarks* on an *Essay upon the Transfiguration*, but never expressly acknowledged them. *Tracts* xv.

8. He added a few short *Notes* to the London edition of Heyne's Virgil, 8vo. 1793; for which he made an agreement with the bookseller to correct the press: but he complained that his corrections were disregarded; and in fact several hundred errors, of no great importance, were suffered to disfigure it.

9. He corrected the Greek text of Æschylus for the Glasgow editions, the folio of 1795, and the two volumes octavo, printed in 1794, but only published London, 1806. The folio is said to have appeared surreptitiously. There are more than two hundred original corrections, and a further number of passages pointed out as corrupt.

10. In the *Morning Chronicle* he published, at different times, a variety of spirited articles of a temporary nature. One of the most amusing was the *Nursery Song* in Greek iambics, 13th April 1796; called *A Fragment of Sophocles*, and signed "S. England," in ridicule of Ireland's pretended discoveries.

11. *Imitations of Horace. Spirit of the Public Journals*, 1797. *Class. Jour.* IV. 97.

12. The first four plays of Euripides appeared separately at different periods. The *Hecuba*, 8vo. London, 1797, Cambridge, 1802, with a Supplement and additional notes; which were also published separately, London, 1808. *Orestes*, London, 1798, 1811. *Phoenissæ*, London, 1799, 1811. *Medea*, Cambridge, 1801; London, 1812. *The four* together, London, 1822.

13. *Collation* of the Harleian manuscript of the

Porson.

Odyssey for the *Grenville Homer*, 4to. Oxford, 1800; with some short notes. Reprinted, *Class. Jour.* IX.

14. Of the *Review of Wakefield's Lucretius*, in the *British Critic* for May 1801, the principal part appears to be Porson's.

15. *A Letter signed J. N. Dawes, Monthly Mag.* Dec. 1802; on some Greek constructions; admitting also an inaccuracy of his own with respect to a hiatus, pointed out by Mr C. Falconer.

16. *A Letter to Professor Dalzel*, dated Sept. 1803; *Mus. Crit.* I. p. 326; in answer to some remarks published in the Professor's *Collectanea Majora*; with an Epigram respecting Hermann in Greek and in English.

17. *Herodotus*, Edinburgh, 1806. Porson corrected the press for the first volume.

18. *Supplement to some Indices, Tracts* xxxvi.

19. It is well known that Porson bestowed considerable pains on the restoration of the text of the *Rosetta Stone*: his *Supplements* were added to the plates engraved by the Society of Antiquaries: they also appear among his *Tracts*, xxxvii. In Dr Clarke's *Greek Marbles*, 8vo. Cambridge, 1809, we find a translation of this inscription, communicated to the editor by Porson, and printed from "a *corrected copy* in his own beautiful hand writing:" but we may here venture to apply Porson's favourite remark on the facility of transposition, and to read, "a *copy corrected* in his own writing," that is, on the margin of Mr Gough's translation, as published in *Duane's Coins*: for the whole is very negligently performed; and it is not a little remarkable that this translation, which was at least approved by Porson, is decidedly less accurate than the Latin translation of Heyne, as appears from the investigation of the enchorial inscription, published in the sixth number of the *Museum Criticum*.

20. A variety of Porson's fugitive and miscellaneous pieces have reappeared at different times in the *Classical Journal*. *Authors cited by the Scholiast on Plato*, II. 619, *Tracts* xxxviii. *The Epitaph*, III. 233; more correctly than in the *Tracts*, but still with a gross error in the punctuation of the last line, which stands, in a manuscript copy of his own, Τέθνηχ', ὃ δὴ τάχιστα πάσχουσ' οἱ 'γαθοί; this reading, though not very elegant, is at least more defensible, than to make πάσχειν alone signify to die, and a phrase to end with ὁ δή! A *Charade* in Latin, VII. 248. Some *Notes on Æschylus*, VII. 456, VIII. 15, 181, X. 114. *A property of the lines* employed in the 47th proposition of the first book of *Euclid*, p. 401. *Notes on Apollonius Rhodius*, XVIII. 370.

21. *Adversaria*, 8vo. Cambridge, 1812. Consisting of *Notes* on the Greek Poets, selected from his manuscripts, and arranged by Professor Monk and C. J. Bloomfield, M A. The first article is an interesting *Lecture on Euripides*, delivered upon his appointment to the Greek Professorship: it is followed by a few miscellaneous observations, and by a large collection of *Notes* on Athenaeus, on Euripides, on the *Fragments of the Tragic and Comic Poets*, on Stobaeus, and on a variety of poets of miscellaneous descriptions. The volume was reprinted at Amsterdam, without any alteration, but the sale of the foreign edition has never been permitted in Great Britain.

22. *Tracts and Miscellaneous Criticisms*, collected and arranged by the Rev. T. Kidd, M. A. 8vo. London, 1815. Besides the articles already noticed as reprinted in this volume, there are a few *Notes on Dawes's Miscellanea Critica*, not before published, No. xli. Some supplementary pages of *Simplicius and Cebes*, reprinted by Porson, for the use of his friends, as restored by Schweighäuser: the want of this leaf of the manuscript of *Simplicius* had given rise to the mistaken assertion that Xenophon was proclaimed a public benefactor at the Olympic Games, on occasion of the return of the ten thousand. There are also some miscellaneous *Notes* on Athenaeus, Menander, and Philemon, Aristides, Pausanias, and the lexicographers, and some *Indices* of authors quoted by Scholiasts.

23. *Notae in Aristophanem*, quibus Plutum comoediam adjecit P. P. Dobree, 8vo. Cambridge, 1820.

24. Gaisford Lectiones Platonicae. Accedunt R. Porsoni *Notae ad Pausaniam*, 8vo. Oxford, 1820.

25. *Photii Lexicon*, 8vo. Cambridge, 1822.

To attempt to form a just estimate of the merit of such a man as Porson, without servilely following the dictates of common fame, or blindly adopting the opinions of others, is a task of no small difficulty, even to one who had the advantage of his personal acquaintance for the last twenty years of his life. But it may safely be conceded to common fame and to partial friendship, that he was one of the greatest men, and the very greatest critic, of his own or of any other age. "Nothing came amiss," says Mr Weston, "to his memory. He would set a child right in his twopenny fable book, repeat the whole of the moral tale of the *Dean of Badajoz*, a page of Athenaeus on cups, or of Eustathius on Homer, even though he did every thing to impair his mental faculties." It cannot, however, be denied, that the talents, and even the industry, that he possessed, might have made him a much greater man, had they been employed in some other department of human intellect. He might *probably* have been as great a statesman or as great a general as he was a scholar, and in these capacities his acquirements would have affected the interests of a much greater multitude of his fellow creatures, than can ever be benefited by the fruits of his erudition; and he might *possibly* have gained more popularity as an orator or a poet, than his refined investigations of grammar and prosody could ever procure him, although it is not by any means certain that his fancy and invention could have been rendered by any cultivation at all comparable to his memory and acuteness. But as far as regards the possession of a combination of the faculties which he did cultivate, he appears to have been decidedly the most successful of any man on record in the same department. On the other hand, it must be admitted that the subjects of his pursuits were in their nature incapable of raising a man to the first rank among the permanent benefactors of the human race; and, if we calmly consider the ultimate objects of prosody and metre, it will appear almost unfair to allow the discoverer of the prosodiacal rules,

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adopted by the ancient poets in their melodrames and choruses, to rank so very high among the luminaries of an age, and yet to look down, with so much contempt as we are accustomed to do, on the character of a modern *Dieu de la danse*, notwithstanding that he thought himself the third great man of his day, with Voltaire and the King of Prussia, for having given soul and sentiment to the measures and movements of the choric representations of the present times. Among the talents of Porson, however, which were so far superior to the importance of the objects on which they were employed, we ought not, perhaps, to consider his remarkable strength of memory as the most to be envied, since many persons who have been possessed of singular and almost miraculous, not to say morbid, memories, have been but little distinguished by any other faculty; and it appears to be possible that a memory may in itself be even too retentive for real practical utility, as if of too microscopic a nature; and it seems to be by a wise and benevolent, though by no means an obvious arrangement of a Creative Providence, that a certain degree of oblivion becomes a most useful instrument in the advancement of human knowledge, enabling us readily to look back on the prominent features only of various objects and occurrences, and to class them and reason upon them, by the help of this involuntary kind of abstraction and generalisation, with incomparably greater facility than we could do, if we retained the whole detail of what had been once but slightly impressed on our minds. It is thus, for example, in physic, that the experienced practitioner learns at length to despise the relation of individual symptoms, and particular cases, on which alone the empiric insists, and to feel the value of the Hippocratic system of "attending more to the prognostic than the diagnostic features of disease;" which, to a younger student, appears to be perfect imbecility. And it is perhaps for some similar reason that many persons, besides Barnes, "of happy memory," have had to wait long in darkness for "the day of judgment." But it must be repeated, that Porson's judgment and acuteness were really almost paramount to his memory, and with the addition of these faculties, his memory naturally rendered him capable of much that would have been impossible without it.

The respect that is justly due to classical learning has frequently been exaggerated in this country, partly, perhaps, on account of the awe which is naturally entertained, by an ingenuous mind, for its instructors in the earliest studies, by which it is advanced towards maturity: and classical learning having most wisely been placed by our ancestors the foremost, in the order of a liberal education, which is most commonly adopted in Great Britain, a personal as well as a general respect has been involuntarily paid to the characters of the individuals concerned, and to the dignity of all those who are engaged in similar occupations; besides that, the means being, by a most frequent inattention of the human mind, confounded with the end for which they are sought, the words and syllables, and the phrases and measures of the Greek and Latin authors have been often the almost frivolous occupation of a valuable life, instead of that of a few of the years of boyhood, which it was intended to devote to them, and which could not have been so well engaged in any other way. It is, however, wholly unjust to stigmatize the study of the classics, and of languages in general, as being confined to words instead of things: for it is utterly impossible that words can be learned, without the acquisition of a considerable degree of knowledge of the things to which they relate, and of the historical facts which they have been employed to express, and without an involuntary modelling of the mind to the elegance and elevation of sentiment, which pervade the works of those authors who are habitually put into the hands of boys in the course of their elementary studies: an acquirement which is of still greater value to the orator and the statesman, than the command of language, and facility of expression, and beauty of imagery, and power of reasoning, which he derives from a perfect familiarity with the great masters of antiquity. But granting all the respect that can possibly be claimed, for ancient literature, we cannot but lament that such a man as Porson should have lived and laboured for nearly half a century, and yet have left little or nothing to the world that was truly and originally his own.

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After the full admission of the very high rank which is due to the comparative merits of Porson's talents and acquirements, it may be thought almost idle, if not invidious, to dwell on any trifling exceptions to their magnitude. But it is, in fact, of high importance to the progress of human knowledge to be aware of the degree in which the first of mankind are liable to error. The admission of the few errors of Newton himself is at least of as much importance to his followers in science, as the history of the progress of his real discoveries; and it is with reason that the detection of an error in such a man is considered as almost paramount to the establishment of a new fact. The English critics have been reproached, and not without some foundation, as paying too servile a deference to Porson's opinions, and it seems to have been very generally believed among them, that it was scarcely possible for him to commit an error or an oversight.

Although Porson was in many respects irregular, and often idle, or even intemperate, yet what he did perform as a critic may be allowed to leave a large balance, at the end of his life, in favour of his general industry, when compared with that of most of his countrymen. It has indeed been asserted, and perhaps with truth (*Classical Journal*, XXI.), that "with things Porson appears to have possessed but a very inconsiderable acquaintance, and not a trace is to be found amidst his writings of that combination of universal encyclopaediacal knowledge with language learning, which is so abundantly found in the *Dissertation on Phalaris,* and the countless pages of Scaliger, Salmasius, and Casaubon." Certainly, however, neither Salmasius nor Casaubon, with all their learning, much less Scaliger, with all his industry and parade, nor even Bentley himself, with all his talent and acuteness, was at all comparable to Porson in his own department, that is, as a sound and accurate and refined Greek critic.

But it must be confessed, that at Cambridge, even although Porson had resolved to make the classics

his principal study, and although there had not yet been many instances of senior wranglers, who were also senior medallists, it was scarcely reputable for a man, with his undeniable abilities, to be only the twenty first of his year in mathematics. Among the literary objects, also, which afterwards engaged his attention, he might easily have found time for the study of some of the modern languages, and he might have derived essential benefit from it on many occasions of critical research. He had, indeed, read a good deal of French, but very little Italian: he had studied the Anglosaxon, but he knew nothing of the kindred dialects of the North of Europe, in which it is preserved almost entire; and he was wholly unacquainted with Oriental literature. He might have profited materially by some of these studies, in deriving from them a clearer conception of the distinctions of the tenses than he seems to have possessed, and he might have enlightened us in no small degree, with respect to the history of languages and of nations, by such etymological investigations, as his comprehensive mind, thus employed, would have rendered him peculiarly capable of pursuing with success.

It has been candidly and very truly admitted by a rival critic in Germany, that Porson committed fewer errors than almost any other person; but it is right to be aware that he has now and then committed some errors, even where he would have been expected to be the most correct. There is, for example, a very strange oversight in one of the criticisms contained in his early review of Weston's *Hermesiananax*, which implies a palpable blunder with respect to the gender of a participle, Ζωρὸν μετροῦσα θυῶν πιοςφυςέης Λυσβιον ἐὲ ὑέλου, "the cup of purple glass, which *measured* the fragrant wine;" and even in a subsequent correction of the same passage, published in his *Adversaria*, he has changed the gender of an adjective in a way that is at least very unusual, if not wholly without example, μετροῦν θυόεντα. A mere omission, in a criticism on another author, would scarcely be called an error in an ordinary person; but in such a critic as Porson, it is very remarkable that he should have neglected to notice, in his catalogue of the *Errors of Le Clerc*, omitted by Bentley (*Adv.* p. 291), the grossest of all Le Clerc's blunders, which is the quotation of the word *Hypophauli*, or *semibarbarous*, from Pollux, with the translation *Sartagines*, or *frying pans*: while the real text of Pollux simply and plainly states that the *Teganismi*, or *fricassations*, in the *Hippocomus of Menander*, is *a semibarbarous* WORD. These instances, which have occurred in a very cursory perusal of some of Porson's works, would certainly not deserve to be noticed, in a general sketch of his character, any otherwise than as exceptions to his perfect infallibility.

It can scarcely be considered as an imperfection in the constitution of Porson's mind, that he wanted that amiable vanity, which is gratified by the approbation even of the most inconsiderable, and which delights to choose for its objects the most innocent and the most helpless of those who are casually present in society. It has been observed that he would neither give nor take praise; and when he was told that somebody had called him a giant in literature, he remarked, that a man had no right to tell the height of that which he could not measure. In fact, having learned "to know how little can be known," it is not surprising that he found himself "without a second, and without a judge," and that he was unwilling to affect a community of sentiment, and an interchange of approbation with those whose acquirements and opinions he felt that he had a right to despise. It might have been wiser, in some instances, to conceal this feeling; but, on the other hand, he had perhaps occasion for something of the habit of retreating into his conscious dignity, from his deficiency in those general powers of ephemeral conversation, which are so valuable in mixed societies: for, with all his learning and all his memory, he was by no means prominent as a talker. He had neither the inclination nor the qualifications to be a fascinating story teller, or to become habitually a parasite at the tables of the affluent; but he was the delight of a limited circle of chosen friends, possessing talent enough to appreciate his merits, and to profit by the information that he afforded them.

There has not yet been a life of Porson that has collected all the particulars that would deserve to be recorded by a biographer, who undertook the task on an extensive scale; but of detached documents there is no deficiency. Mr Kidd has pointed out almost every work in which his name has been mentioned: the most material articles relating to him will be enumerated here.

Morning Chronicle, 6th October 1808. *A short Account of the late Mr Richard Porson, with some particulars relative to his extraordinary talents*: By an admirer of great genius (the Rev. S. Weston), Μηκέτι πάπταινε κόρσιον, Look for nothing beyond him. 8. Lond. 1808. Republished, with some additions, under the title of *Porsoniana, or Scraps from Porson's rich feast*, 8. Lond. 1814. Bloomfield's *Sapphic Ode, Class. Journ.* I. 1. *Some anonymous Iambics*, p. 81. *Sale of his Library*, p. 385. *Athenaeum*, IV. 426, 521, v. 55. *Class. Journ.* IX. 386. Savage's *Librarian*, I. 274. *Gentleman's Magazine*, LXXVIII. *Monthly Magazine*. *Dr Adam Clarke's Narrative*. *Class. Journ.* II. 720. *Correspondence of Wakefield and Fox*, 8. Lond. 1813. *Greek Epitaph, Class. Journ.* XXIII. 179; making Porsōnum equal to Newtŏnus. Aikin's *General Biography*, X. 4. Lond. 1815. Kidd's *Imperfect Outline*. *Tracts*, 1815. Chalmers's *Biographical Dictionary*, XXV. Lond. 1816. (R. T.)

PORTUGAL.—This kingdom, the origin of whose name is discussed in the *Encyclopædia*, had different limits assigned to it by the Romans, who possessed it under the name of Lusitania. Its northern boundary was the river Douro, whilst eastward it extended over a large part of Leon and Castile. Its line of demarcation passed from the bridge of Arzobispo to the eastward of Talavera, extended to Simaņacas on the Douro, and included within its bounds the cities of Salamanca, Truxillo, Coria, Merida, and Avila, and the several intermediate towns and villages. When the northern tribes penetrated to the peninsula, and gained the mastery of it, Lusitania still retained the same name, and a

branch of the Suevi, having established themselves in it, made Braga the capital of their government. Though under the Moors, the names of many cities, towns, rivers, and mountains, received the nomenclature of that people, yet the whole country retained the Roman title till the more modern name of Portugal was bestowed upon it.

Limits and Extent.

The present kingdom of Portugal is bounded on the north by the Spanish province of Galicia, on the east by the several provinces of Leon, Estremadura, and Andalusia, and on the south and west by the Atlantic Ocean. It has the figure of a parallelogram, with its longest side from north to south; extending from 37° 3′ to 42° 12′ north latitude, and from 6° 15′ to 8° 55′ west longitude from Greenwich. Its extent is estimated, following the map of Lopez, at 3437 square leagues, or about 22.765.000 English acres. The divisions of Portugal, like those of most of the other kingdoms of Europe, have been derived rather from feudal possessions than from any other cause, and though they have produced great inequalities in their extent, in their relative and absolute population, and in their fertility and wealth, there is no reason to expect any alteration in them; they are as follows, according to Antillon, viz.

Provinces.	Population.	Extent in Square Leagues.	Extent in English Acres.	Number of Acres to Inhabitants.
Entré Duero e Minho	907.965	291	1.927.040	$2\frac{1}{8}$
Tras los Montes -	318.665	455	3.007.760	$9\frac{5}{8}$
La Beyra -	1.121.595	753	4.936.880	4
Estremadura -	826.680	823	5.450.880	$4\frac{1}{8}$
Alemtejo -	380.480	883	5.848.320	$15\frac{7}{8}$
Algarve - -	127.615	232	1.536.000	12

Population.

The population here given is the result of the last actual census, which was taken in the year 1798, by order of the late queen. The enumeration then made was of the number of families, which, being multiplied by five, gives the state of the population here expressed. Notwithstanding the desolating war which has since occurred, and which must, for a time, and within certain districts, have lessened the population, the best native authorities contend, that, during the last twenty years, the increase has been gradual, and that the number of inhabitants now is nearly equal to that census.

Portugal may then be considered a well peopled country; as compared with Spain, the density of population is as 3 to 2, and as compared with Scotland, which is of nearly the same extent, it is almost double. If the whole of Portugal were as thickly settled as the province of Entre Duero e Minho, the number of souls would amount to 10,700,000; whereas, if the whole had no greater density than that of Alemtejo, they would not exceed 1,480,000. An ingenious writer, in comparing the present population of the kingdom with its state in the fifteenth century, remarks that, "in the provinces where commerce flourishes the inhabitants have increased; where they subsist by the fisheries they have diminished; and where both commerce and the fisheries exist, the increase has been only in proportion to the quantum of commerce."*

Face of the Country and Roads.

The face of the country is generally mountainous, divided into ridges by deep chasms, through which rapid torrents rush, in the rainy seasons; but which, in times of drought, scarcely afford sufficient supplies of water for the wants of the inhabitants and their cattle. This irregular surface of the country is very unfavourable to intercourse between the different provinces. The expence of constructing roads and bridges in such a country is too great to be borne by its inhabitants. Hence, there is scarcely any conveyance either for goods or passengers by wheel carriages. Although, in the northern parts of the kingdom, there are some bridges of very ancient erection, yet in the south scarcely any are to be found. The roads, too, in the north are, in some few instances, tolerably good. The merchants of Oporto have constructed a road to Lamego for the conveyance of their wines, and are still extending it. A good road has been formed to Mafra, and the Government has been occupied in making one to Coimbra. In the southern provinces no such efforts have been made; but the road from Mertola to Beja, originally constructed by the Romans, has been recently repaired. At present none are likely to be commenced, so that the inconveniences of travelling are perhaps greater than in any other part of Europe.

Agriculture.

The state of agriculture was till lately very bad; and though much of the soil is naturally fertile, and the climate highly favourable to the production of all the necessaries of life, yet Portugal did not raise more corn than was sufficient for one third of its annual consumption; and though animal food can scarcely be deemed an article of general sustenance, its own lands did not pasture cattle sufficient for the scanty demand of the inhabitants. When cultivated with care, the soil produces abundant crops of wheat, barley, maize, and rice; besides which, it yields hemp and flax of excellent quality. Some improvements in husbandry have, however, begun to appear. The cultivation of potatoes has been introduced, and, on the more elevated parts of the country, with great success. They have extended rapidly, and form already so large a part of the sustenance of the inhabitants, that the exportation of flour from the United States of America has nearly ceased; and the small quantity of corn now required is drawn from the northern parts of Europe, or from the Cape de Verd Islands.

The attention of the Portuguese husbandmen is principally directed to the production of those articles which find their most ready vent in foreign countries, or which are raised with the least labour. Of the first sort is their wine, chiefly in the

* *Memoiras Economicas de Academia Real das Sciencias de Lisboa*, Tom. I. p. 123.

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northern provinces. The quantity usually made is about 80,000 pipes of red, and 60,000 pipes of white. Of the former about one half is sent to England, about one eighth to the other parts of northern Europe, and the remainder to Brazil. Not more than one sixth part of the white wine is exported to all the countries of Europe; the rest is either sent to Brazil or is consumed at home; but, in general, the natives drink wine of a quality far inferior to any that could find a vent in foreign markets. The productions that require but little labour, such as chesnuts, almonds, oranges, lemons, and citrons, are profusely raised; and, with the onions and garlic, form no small proportion of the aliment of the inhabitants. Olive trees are plentiful, and the oil expressed from their fruit forms an important article of sustenance; and though not of a quality or flavour that is relished for the table in foreign countries, it is a considerable article of export; being used by the woollen manufacturers of England, Holland, and Germany, in their respective operations.

Fisheries.

The sea coasts of Portugal abound with excellent fish, especially with Tunnys and Sardinias, and they, as well as the rivers, afford both occupation and food to a great portion of the inhabitants; but the supply from them is inadequate to the wants of the population, whose consumption of that kind of diet, from their adherence to the fasts prescribed by the Catholic religion, is very great; requiring an annual importation of salted fish, which is furnished by the English and Americans, from the banks of Newfoundland, and by the Swedes, Norwegians, and Dutch.

Manufactures.

The manufactories of Portugal are in a very languid state. With the exception of the lower classes of people, who are clothed with their domestic manufactures, or with the skins of their sheep, nearly the whole of the nation may be said to be furnished with their apparel from England, Holland, and Germany. The few manufactures of Portugal are those of cotton, at Alcobaza and Tomar; of linens, at Guimarens, on the Ave; of glass, at Leyria; and of woollen cloths, at Guarda. The best goods that are made in the kingdom, as compared with those of other countries, are the cambrics, shirting and table linens, and sewing threads. In Lisbon are made some silks, hats, and silver and plated wares. A late most superb service of plate, presented to the Duke of Wellington, made wholly by natives, shows that they are not deficient in taste in the goldsmith's art.

Minerals.

The mineral riches of Portugal have been much neglected. There are mines of tin which were formerly worked to considerable extent, and much profit, but are now abandoned. Besides these, there are veins of silver, iron, lead, and copper, none of which are wrought. The country abounds with most beautiful marbles, though many of the quarries are at so great a distance from water conveyance, and the roads are so bad, that they will not repay, in the present condition of the kingdom, the expences attendant on carrying them to a market.

Commerce.

The emigration of the court to Brazil destroyed that colonial monopoly which, till that event, was most rigidly maintained. Instead of being the point in which both the wants and the produce of the colonies met, and were exchanged, the imports have been confined to what the parent state has required for its consumption; and the exports have been restricted to the wines, oil, and fruits, which were sold to purchase the corn and other sustenance required to feed the people, and procure clothing from England and Holland. The sugar, cotton, and other productions of Brazil, are carried direct to the places of consumption; and from the same places the Brazilians obtain their supplies of European commodities, without the intervention of Portugal. Next to wine and fruits the chief export from Portugal is the bay salt, made from sea water, by natural evaporation, at St Ubes. The vessels which bring salted fish usually take a part of their returns in this article. Near five hundred vessels are annually loaded with salt, at St Ubes, and the quantity exported is about 100,000 tons. Of late years wool has been transported to England; in one year nearly one million pounds weight; but a tax laid on that commodity here has operated nearly to exclude that of a coarse quality from our markets.

Government and Laws.

The government of Portugal was a monarchy of the most absolute kind. The several Boards or Councils, which carried on the administration, had no check or even voice in the measures that were adopted, but obeyed the orders of the King implicitly; and it is generally understood, that in no Court did corruption and favoritism abound to an equal extent. The laws were a most incoherent mass, without fixed principles or regularity; and the administration of them, whether by superior or inferior judges, was perverted by bribery, so as to favour the purposes of oppression rather than of justice.

Religion.

The religion of the kingdom is the Roman Catholic, of the most rigid, not to say of the most superstitious, description. The proportionate numbers of the clergy were greater than in any other country in Europe. There are three archbishops, thirteen bishops, and a prelate presiding over them, denominated the patriarch. The Inquisition was in full force, to check, in their earliest stages, the growth of any opinions that were thought to militate against the established faith. By some late regulations the number of the clergy has been reduced, and the Inquisition abolished.

Finances and Military Strength.

Before the invasion by the armies of Buonaparte, the revenues of Portugal, including the sums drawn from Brazil, were calculated to amount to about 3,000,000 Sterling. At the same period, the land forces consisted of 30,000 men; and the marine comprised 20 sail of the line, besides frigates, corvettes, and sloops. During the war, resources were called forth which the nation never had imagined it possessed. Troops, notorious for indolence, want of discipline and filthiness, when placed under the command of British officers, became active, disciplined, and brave; and bore no inconsiderable share of the dangers and successful contests which liberated their own country, Spain,

and ultimately the whole of Europe. When the Court emigrated to Brazil, where the marine of its ally was a better protection than any she could furnish, Portugal suffered her navy to dwindle, and she has now few large ships that are capable of warlike operations.

People and Language.

The inhabitants of Portugal are generally a robust, yet not an industrious people. They are enterprising and persevering, patient in adverse circumstances, excessively attached to their own religion and customs; and, though temporary circumstances may seem to indicate the contrary, they retain a high sense of loyalty to their monarch, and of submission to their spiritual superiors. The Portugese language is derived from the Latin, of which it contains a great proportion of words, though mixed with many others of Arabic origin. In the construction of its sentences, it very much resembles the Castillian; but the pronunciation of the syllables differs considerably; and there are many words introduced which are peculiar to itself, and whose derivation it is difficult to trace; though probably they are to be found among some of the tribes on the coast of Barbary.

Cities, Towns, and Ports.

Portugal contains twenty-two cities. The capital, Lisbon, on the north side of the Tagus, distinguished by its excellent harbour, by some superb buildings, its irregular surface, and disgustingly filthy streets, contains 260,000 inhabitants; Oporto contains about 65,000; Coimbra, 15,000; Evora, 12,000: the other cities are small, poor, and less populous. The remainder of the inhabitants occupy 647 towns and 4262 villages. The proportion of agricultural labourers to the whole population is so small, that, scanty as are their harvests, and favourable as the weather almost uniformly is for securing their fruits and corn, the labours of the field, in autumn, require numerous additional hands, which are furnished by the adjoining Spanish province of Gallicia. The principal sea ports are Lisbon, Oporto, and St Ubes. Besides these, Viana, at the mouth of the river Lima, Aveiro, Sines, Serdao, Villa Nova, Faro, and Tavira, have harbours, but generally accessible only to small vessels; and, except Viana and Faro, they have scarcely any other than a mere coasting trade.

Recent History.

The *Encyclopædia* brings down the history of political events in Portugal to the conclusion of the Convention of Cintra in August 1808. Towards the close of that year, the armies which Spain had collected to oppose the invading forces of France being dispersed, Madrid having surrendered, and the British troops under Sir John Moore having been compelled to a precipitate retreat from the Peninsula; the invasion of Portugal was again resolved upon by the French with the fullest confidence of success.

Three armies were collected on the frontiers. One under Marshal Soult in Gallicia, a second under General Lapisse at Salamanca, and a third on the banks of the Tagus under Marshal Victor. The only opposition which could be presented was to the last of these corps, by an assemblage of the fugitives of the Spanish army which General Cuesta was attempting to reorganize. Consternation and dismay spread over the kingdom; the garrison and stores were withdrawn from the frontier fortress of Almeida; the forts and batteries on the Tagus were dismantled; and the British troops in the vicinity of Lisbon were concentrated as preparatory for instant embarkation. A war breaking out again, at this period, between Austria and France, induced Buonaparte to withdraw from Spain, and to take with him 15,000 of his best troops, which in some measure checked the rapid advance of his forces, and allowed an interval for preparation, which was sedulously improved in Portugal. General Beresford, who had acquired the confidence of the natives, was, at the suggestion of the British Government, appointed Marshal and Commander-in-Chief of the armies of Portugal. Twenty thousand of the Portuguese were taken into the pay of England, and British officers were nominated to the superior commissions in each battalion; by which means a general system of discipline and subordination was quickly established. Reinforcements of troops from England, augmenting the army to 17,000 men, had reached Lisbon, and confidence was in a great measure restored before a blow was struck.

Marshal Soult at length having dispersed the Spanish troops in Gallicia, and thus secured that province, entered Portugal by the road of Chaves. He was slightly opposed by General Friere, at the head of a Portuguese army, who had intended to have retired, on his approach, to stronger ground nearer Oporto. In this design he was interrupted by the mutiny of a division of his troops, who, insisting on defending Chaves, were shut up in that town, and in a few days compelled to surrender. As Soult advanced, Friere would have retreated, but the rest of his army being without due subordination, were impatient to fight; and as he persisted in his prudent plans a mutiny arose, when, under the suspicion of treachery, the General and his Staff were massacred by the mutinous troops. They then demanded a British officer who would lead them to attack the enemy. Baron Eben, a German in the British service, took the command, and gratified their wishes by fighting the unsuccessful battle of Carvalho da Este, where, after some creditable efforts of individual bravery, the sabres of the enemy's cavalry took ample vengeance on them for the murder of their late Commander. Soult then invested Oporto, which had been strongly fortified, and was defended by 200 pieces of cannon, and a garrison of 20,000 men; but the same insubordination and want of confidence prevailed in the city as had produced the disasters in the field; and, after an ill conducted defence of three days, it was taken by assault on the 29th March. The French soldiers, on entering the town, made an indiscriminate slaughter of the inhabitants, and delivered themselves up to every species of plunder and licentiousness; and, though their Commander used efforts to repress their fury, he was unable to accomplish it before the sufferings had continued a whole day and night.

1809.

The day before the fall of Oporto, Victor had defeated the Spanish army commanded by Cuesta in the battle of Medellin. This event opened to the

Portugal. French an easy road to Lisbon. General Craddock, the British Commander, posted a corps of his army of 6000 men at Abrantes, assembled the main body of his troops at Leyria, and the Portuguese army at Thomar.

Such was the situation of affairs in Portugal when, on the 22d of April, Sir Arthur Wellesley landed at Lisbon to assume the chief command of the armies of England and Portugal.

The ill consequences of independent Commanders were visible in the movements of the French. The three armies of Soult, Victor, and Lapisse, which, if directed by one Chief, would long before this period have entered Lisbon in triumph, being disunited, and fearing to be separately committed, lost the precious moments for action in suspense, or petty movements. Soult remained nearly a month at Oporto, in expectation of intelligence from the other Commanders, without which he deemed it imprudent to move forward. In the meantime, the Portuguese troops had captured Chaves, and thus cut off his direct communication with Spain by that route. The movements of Lapisse and Victor were equally hesitating. Sir Arthur, on the other hand, being unfettered in his views, could act with decision and promptitude. On the tenth day from his landing, the British in Leyria, to the number of 16,000, began to move by Coimbra and Aveiro, for the recovery of Oporto; whilst 6000 Portuguese under Beresford marched to cross the Douro at Lamego, and cut off the enemy's retreat by Amarante; and the forces at Abrantes were left in that city to keep in check the army of Victor. The British from Leyria first met the enemy on the 10th May, on the banks of the Vouga, and, after a slight affair, drove them over the Douro. The floating bridge across that river was destroyed, and all the boats near Oporto were secured by the French on the right bank; thus the British General found himself separated from his antagonist by a rapid river, nearly 300 yards broad, without any means of effecting the passage across it. Sir Arthur then planned and successfully executed the boldest passage of a river that is to be found on military records. He detached a body of troops under General Murray to Avintas, five miles higher on the river, where, if boats could not be found, a ford would admit of the troops passing; and sent General Sherbrook with the Guards to the common ferry below the city; whilst from the Serra Convent, nearly opposite the town, he directed the passage in person. The stream was excessively rapid, and the heights on the right bank considerable. By the aid of some inhabitants, two boats were brought over from the enemy's side, and in them, protected by the fire of a brigade of light guns, three companies of the Buffs were ferried across. Soult, either despising the effort, or believing it to be merely a feint to draw his attention from the main object, did not oppose the landing, but gave time to General Paget, who commanded, to ascend the bank, and place the troops in a formidable attitude in a ruined building before he attacked them. He then brought up a considerable force, which was firmly resisted, and gained time for passing over several other battalions. General Paget was early wounded, and the command devolved on General Hill, who was warmly engaged in contesting the post, when General Murray appeared in sight, marching on the enemy's left flank. The Guards were then pushed across, and the French precipitately retired into the city. Soult discovered that he had been out-manœuvred, and ordered the immediate retreat of his army; but the British were already in the town, and charging up the streets. The confusion and precipitancy with which the French fled was far greater than can be readily imagined, and their panic seemed to increase as they gained the open country. Never was the rout of an army more complete, when night put an end to the pursuit, and gave the enemy a few hours respite. Soult, finding the bridge at Amarante destroyed, abandoned all his artillery and wheel carriages, and leaving the high road, took the mountain track to Guimaraens. Thus freed from every incumbrance, the badness of the roads favoured his flight, and he gained a narrow pass on the shore near Salamonde, before Beresford's troops had reached the spot, as was projected, to intercept him. On the 18th he reached the frontier, and the pursuit closed, as more important affairs required attention to the south. Victor had joined with Lapisse, and forced the passage of the Tagus, at Alcantara; from whence they were advancing towards Lisbon at the time that the victorious army from Oporto reached that river early in June; when the enemy retired into Spain, and abandoned Portugal for the present.

1810. When Buonaparte had compelled Austria to conclude a peace, he stood pledged to his people and to the world to conquer Portugal, and "to drive the British into the sea." His means for effecting those objects appeared unlimited; whilst the English nation, desponding at the general ill success of the war, and dissatisfied with the waste of their military strength in the Scheldt, were generally disposed to withdraw from the contest.

Early in March, however, the Parliament deciding with the administration to continue with vigour the defence of Portugal; the subsidiary force of that nation was increased to 30,000 men; and such of the British battalions as could be rendered effective after the effects of the climate of Walcheren, were sent out to reinforce the army. The French assembled an army of 72,000 men under Marshal Massena, in the vicinity of Salamanca, early in April; which could only be opposed by about 50,000; one-half composed of young Portuguese levies, yet untried in general action. The operations of the campaign commenced by the siege of the Spanish city of Cuidad Rodrigo, which, after a stout defence, capitulated on the 10th July. The road to Portugal was thus opened to the French, who entered it, and besieged Almeida. Owing to an explosion, by which all the powder in the garrison was destroyed, the Commander was compelled to surrender the latter end of August. The road by which Massena intended to force his way to Lisbon, soon became evident to the rival commander, and the united British and Portuguese armies were placed in such positions as were most likely to frustrate his intentions. The British Commander, during the whole progress of the enemy, had employed the abundant means at his disposal in constructing a secure asylum in which he

Portugal. could effectually make a head against the superior forces that were employed to drive him from the Peninsula, and to possess the capital of Portugal. Lisbon is situated on the extremity of an isthmus formed by the ocean and the river Tagus. Across this peninsula nature had drawn the outline of a strong defensive position, which the military art had been secretly but sedulously employed in rendering perfect. A track of country, thirty miles in extent from the mouth of the small river Tirandra to Alhandra, on the Tagus, was modelled into a field of battle; mountains were scarped perpendicularly, rivers dammed, and inundations formed. All roads that could favour the enemy were destroyed, and others made to facilitate the communications of the defenders; formidable works were erected to strengthen and support the weak parts; whilst numerous cannon, planted on inaccessible posts, commanded the different approaches to them, and gave an equality of defence to the whole position. Behind these defences the inhabitants of a district of nearly 2000 square miles were invited to retire with what of their substance they could convey, and were directed to destroy whatever could not be removed, that might afford support to the advancing army of Massena. Though these orders were but partially obeyed, yet, as far as they were executed, they contributed to the ultimate success of the defensive plan formed by Lord Wellington.

With this secure asylum in his rear, the British Commander could safely practise all the manœuvres which tended to retard the approach of his antagonist. Massena, after the capture of Almeida, pushed on with rapidity towards Coimbra, and meeting no opposition there, expected the British army was hastening to Lisbon to embark. He received a check at the mountains of Busaco, but having turned that position, the British slowly marched within the formidable lines so celebrated in military annals by the name of *Torres Vedras*. The day after the 9th of October Marquis Romano joined the British army with 6000 Spanish troops; and on the next day Massena first discovered the formidable works which covered his antagonists. "To judge," says an eye-witness, "from the instant halt he made, and from the retrograde movement which followed, as soon as it became dark, they struck him as much with dismay as astonishment, and three days elapsed before he again ventured to the same spot." After some slight efforts to ascertain the nature of the defences, the French remained a month without any movement, merely sending out strong parties to their rear to ascertain the nature and resources of the country, from which alone they could hope to draw sustenance. The irregular troops of Portugal pressed him on all sides, and contracted the limits from which supplies could be obtained; and a division of them captured the sick and wounded of the French to the number of 5000 men, which, in the haste of his progress, Massena had left at Coimbra.

On the 14th November the French army, to be nearer their supplies, retrograded towards Santarem and Thomar, where they fortified their position, and were followed by the British to Cartaxo, from whence they were ready to fall back on their lines, should the enemy receive such reinforcements as to render it necessary. In this situation the two armies remained; the English receiving from Lisbon abundant supplies, which were sent by sea, and the French exhausting the country in their rear till scarcity produced disease, and rapidly thinned their ranks. Though reinforcements were sent to them, the desolate state of the country made them a burden, rather than an assistance to their coadjutors. After thus remaining in sight of each other till the 7th March 1810, a period of five inactive months, without a prospect of decisive action, the French were compelled to commence their retreat, just at the moment when the British had received a reinforcement of 7000 fresh troops. At the commencement of their retreat the loss in the French army since it had entered Portugal amounted to more than 30,000 men. Disgusting accumulations of filth, and remains of the most unhealthy kind of food, with the wretched and squalid appearance of most of the prisoners, and the neglected and unprovided state of the hospitals, sufficiently testified the miserable condition to which the invaders were reduced, and accounts for so prodigious a mortality beyond that inflicted by the sword. The sufferings and losses of the French, however, were nothing in comparison with those which their visitation had inflicted on Portugal and its inhabitants. A wide extent of country remained for five months with scarcely an inhabitant: every thing it contained was devoured by the enemy or destroyed by the season. In the space immediately bounding the positions of the two armies, which was not permanently occupied by either, the harvest perished in the ground, and the fruit fell rotten from the trees; flocks of innumerable small birds, as if drawn to the spot by instinct, fattened unmolested on the ungathered grapes; and latterly the very wolves, conscious of security, or rendered more daring by the absence of their accustomed prey, prowled about, masters of the territory, reluctantly giving way to the cavalry patroles which occasionally crossed their track.

Many of the wretched inhabitants who had neglected the warning voice that invited them within the lines, passed the whole season of winter, exposed to its inclemencies, in the neighbouring woods or mountains, subsisting merely on roots and herbs; and on the advance of the allies, returned to their ruined homes with bodies emaciated from abstinence, and intellects impaired by long continued apprehension; among these were girls of 16, who, become ideots, resembled in person women of 50. At the departure of the French, in many districts neither a living animal nor an article of subsistence was to be found. The official account of the *Moniteur* correctly and unblushingly states, that "the towns and villages were deserted, the mills destroyed, the wine running in the gutters, the corn stalks burnt, the furniture broken; and not a horse, a mule, an ass, a cow, or even a goat, to be seen."

The retreat conducted by Massena exhibited great military talents, and every movement was made with such skill and celerity, that his active and indefatigable opponent could gain but few advantages over him. The rapid pursuit in a few days carried the

allied armies farther than their supplies could reach them, and they were obliged to halt till provisions could overtake them. Massena availed himself of these circumstances to retire out of Portugal, after throwing supplies into the fortress of Almeida. The retreat of the French was conducted with so much ability, that its loss, both by the sword and in prisoners, did not exceed 5000 men; that of the allies being under 650. Having thus freely bestowed the tribute of praise justly due to the French as soldiers, it is but proper to notice their conduct as men, and to state, on the authority of an eye-witness, that the unnecessary cruelties and wanton devastation which marked every step of their retreat, were such as to cast a shade over their character which no military glory can efface, and to stamp them rather as sanguinary and unprincipled banditti, than as the organized warriors of a civilized state.

The French army was reinforced and refitted at Salamanca, returned to Portugal in the beginning of May, and made several movements and attacks, some of a very important nature, to prevent the British from capturing Almeida; but having been foiled in every attempt, they retired and left that fortress to its fate; the garrison of which evacuated it, and forced their way in a most spirited manner through the British army that surrounded them. With this operation the scene of war closed in Portugal; for though, during the sieges of Cuidad Rodrigo and Badajoz, and in the attempt made by Marmont, some parts of that kingdom were included in the theatre of hostilities, they never extended beyond the frontiers. The other events of this important war belong rather to the history of Spain and of France than to that of Portugal, though in all the operations the troops of that nation bore an active and conspicuous part.

After the dissolution of the government of Buonaparte, the troops of Portugal were marched to their own country; but before the proper measures for reducing their numbers were adopted, his return from Elba again set them in active movement, till the decisive battle of Waterloo once more permitted them to rest. The state of the country was, however, by no means tranquil. The absence of their Court in Brazil, the little influence enjoyed by the Regency, the calls for pecuniary aid from the Provinces, and especially the large army being still kept up, and its command continued in foreign hands, with the spirit of insubordination prevailing among the native officers, gave sufficient grounds to apprehend that convulsions must ensue. A conspiracy, of a very extensive nature, was timely discovered in the army, and its progress checked, but without the spirit which generated it being extirpated. This was strongly exhibited afterwards, when 10,000 men, who had been ordered to embark for Brazil, revolted, and showed such determination, that the Regency was compelled to yield to their wishes. Portugal felt that the order of nature was inverted, and the parent state become a dependent on her own colony. Conflicting claims between the Regency and the Commander of the Forces induced Lord Beresford to repair to Rio de Janeiro, to obtain fresh instructions, and probably additional authority from the King. In his absence a revolution broke forth, which, giving to Portugal a new aspect, renders all accounts of its present condition doubtful, and leaves to conjecture what may be the result of the circumstances in which she is placed.

The first symptoms of this revolution were exhibited at Oporto, and the first movements were made on the 24th August 1820, in the 18th regiment, under the command of Don Bernardo de Castro e Sepulveda, in which he was supported by the other troops in that garrison, and, as is supposed, by the civil authorities of the city. A provincial Junta of 13 members was chosen by acclamation, who issued a proclamation to quiet the apprehensions of the British officers. Sepulveda was opposed by Count Amarante, the commander of the troops in the province Tras os Montes; but on marching towards him, in the end of August, that officer was forsaken by his troops, who joined the insurgents, and rendered it necessary for him to take refuge in Spain.

Sepulveda then advanced with his army towards Lisbon, and reached Coimbra, where the Junta of Oporto followed him and held their sittings. The Regency of the kingdom in Lisbon acted with indecision, or perhaps with treachery. On the 29th August, they issued a proclamation denouncing the transactions that had taken place at Oporto, and calling on the inhabitants and military to oppose their progress; and, on the 1st September, issued another, by which they directed the assembling of the Cortes of the kingdom according to its ancient institution. Before the period had arrived for the convocation of the assembly, an event occurred which wholly frustrated the plan projected by the Junta of Regency. It had been usual to celebrate, on the 15th September, the deliverance of Portugal from the French invaders. The Junta fearing to assemble, in the agitated state of the public mind, such a concourse of people as usually met on that day, resolved to omit the ceremony; but the troops, at the instigation of the native officers, paraded without orders, and, before they separated, deposed the Government, and installed a temporary Council to rule. The Junta of Oporto, who were at Coimbra, soon received intelligence of the occurrences in Lisbon, and reached the capital on the 1st October. Before any agreement between the two Juntas had been made, the arrival of Lord Beresford, from Brazil, in an English ship of the line, caused great consternation. The soldiers were known to be attached to him, his powers were presumed to be extensive, and the acclamations which the native officers had drawn forth from the troops could not be depended on. The two Juntas, agreeing in nothing else, united, however, to prevent his landing; and after some ineffectual efforts to open an intercourse, he departed for England. When left to themselves, divisions of the most embittered kind arose among the insurgents. The partizans of the Junta of Oporto were the most furious; and having placed at the head of the troops one of their own partizans, the Junta of Lisbon was surrounded on the 11th November, the meeting dissolved, and a proclamation issued declaring the adoption of the Spanish constitution. The ascendancy of this violent party was but short. Texeira, who had com-

manded the troops, changed his views; and through his means the more moderate party were put in possession of power. By them the Cortes was convoked, and the Spanish constitution voted as far only as it should suit the circumstances of Portugal. The mode of election of one deputy to 30,000 inhabitants, as prescribed by the Spanish plan, was adopted; and when the assembly met, it was found that few men of wealth or family were chosen. The assembly assumed all power, uniting the executive, judicial, and legislative authority, in their own body. The King was induced to return from Brazil, but on his arrival found himself a mere cypher; every one in whom he had any confidence being carefully kept from his presence, and some of the ministers, who had accompanied him, being committed to prison. The Cortes have since occupied themselves in framing a constitution and a code of laws; but have made no such progress in either as can enable any certain judgment to be formed of what may be the result of their deliberations. In the meantime, the inhabitants of Brazil have established a government, in effect independent of Portugal, with the Prince Regent at its head. The troops that have been sent to that country have revolted to the Brazilians, and their officers being dismissed, have been sent back to Europe. The state of the finances has so much deteriorated, that there is not money sufficient to pay even the troops, who are six months in arrear; and the civil officers and creditors of the state are in a still more lamentable situation. There is no power to put in execution the decrees that issue from the Cortes; and that body has not sufficient unity of mind to enact a series of laws consistent with themselves.

Whether it was wise to attempt the establishment of a democracy, in a country where the priests of various kinds, the military, and the officers of the state, comprise one-fifth of the male population, it is not for us to determine; but so wretched was the previous condition of the Portuguese government, that it is scarcely possible the revolution can leave the country in a worse state than that which preceded it.

See *Elementos de la Geografia Natural y Politica de Espana y Portugal*, por Don Isidoro de Antillon. *Memoria sobre as causas da differente populacaõ de Portugal*, por Jozè Joaquin Soares de Barros. Link's *Travels through France, Spain, and Portugal.* Jones's *War in Spain and Portugal.* *Campagnes de l'Armée de Portugal*, par M. Guingret, Chef de Batallion. *Essai Statistique sur le Royaume de Portugal*, par Adrien Balbi. (W. W.)

GUN-POWDER.

History of Gunpowder.

The invention of gunpowder is popularly ascribed to Barthold Schwartz, a German monk and alchemist, and the date of the discovery is further supposed to have been in 1320. The prior claims of our countryman, Roger Bacon, such as they are, are however unquestionable; as this substance is described in his writings about the year 1270; or eighty years before the time of the supposed discovery of Schwartz. But even Bacon has as little title to this invention as his supposed rival; nor, indeed, when we examine his own description of this then wonderful compound, do we perceive that he makes any claim to have been the discoverer. On the contrary, he quotes it as a well known substance, in common use all over the world for making squibs to amuse children. So pertinacious are vulgar errors. The passage in Bacon stands as follows: "Ex hoc ludicro puerili, quod fit in multis mundi partibus, scilicet, ut instrumento facto ad quantitatem pollicis humani, ex violentia salis qui salpetræ vocatui, tam horribiles sonus nascitur." This is the description of a parchment cracker. "In ruptura tam modici pergameni, quod fortis tonitrum excedere rugitum et corruscationem maximam sui luminis jubar excedit." Thus the claim is shifted without difficulty from Bacon, and, as Dutens thinks he can show, is removed to Magnus Græcus, whose MS. he quotes, and from which he presumes that Bacon derived the invention; although, by his own showing, Bacon need not have consulted an obscure writing for an invention of general notoriety. The title of the MS. in question is as follows: "Incipit *Liber Ignium* a Marco Græco perscriptus, cujus virtus et efficaciu est ad comburendum hostes, tam in mari quam in terra;" so that even the military uses of gunpowder were then known. In the same MS. are contained directions for making a rocket, which we dare not quote on account of its length, but it is such as to prove that the nature of this firework was thoroughly understood. It is even remarkable that he recommends particularly the charcoal of willow wood, which we moderns have found by experience to be among the best for all the purposes of gunpowder.

Thus far, although we have not fixed the date of the invention, we have carried it, not only beyond Bacon, but even beyond this supposed predecessor; as he himself does not pretend to be the inventor, but the compiler, of a *Liber Ignium*; a treatise on pyrotechny. If, in attempting to ascend still higher, the evidence becomes more rare and more obscure, there are still insuperable facts to prove that its antiquity is far greater; however impossible it may be to approximate to the date of the invention, far less to assign that which seems buried among the obscurities of Oriental learning. The question of gunpowder, as applied to Artillery, is a separate one; but there is abundant reason to believe that this compound was not only used in some form or other as an explosive and combustible substance, but was even applied to military purposes; it may be in the shape of rockets or other fireworks, which, for objects of amusement at least, have been familiar to the Chinese beyond all record.

The earliest date to which we can refer the knowledge of gunpowder, in defect of a sufficiently re-

mote acquaintance with Oriental History, is 355 A. C.; although, from the very nature of this evidence, it follows that it was then not only known to the eastern nations, but that it must have long been so; since, even at that early period, it was applied to warlike purposes. In the code of Hindoo laws, indeed, where it is mentioned, it is referred to a period which Oriental antiquaries have considered as coincident with the time of Moses. But the evidence to which we more particularly allude, is found in a passage of the Life of Apollonius Tyanæus by Philostratus, ; the purport of which is, that Alexander was unwilling to attack the Oxydracæ, who lived between the Hyphasis and the Ganges, because they were under the care of the gods, and overthrew their enemies with thunder and lightning, which they shot from their walls. The same tale is told of the repulses experienced in this country by Hercules and Bacchus.

The next of these early dates, in which also our evidence is imperfect, is 212 A. C., but the establishment of the truth of the last would render this one more credible. In the defence of Syracuse by Archimedes, Vitruvius relates that one of his engines threw large stones with a great noise; a description which does not apply to any of the mechanical artillery of the ancients. On a notice so superficial, we must not, however, lay too much stress; and here ends all the information which we have yet procured respecting the earliest knowledge of gunpowder. It seems, however, to be so decidedly capable of being traced from the East, through the intervention of the Arabs, that there can be little doubt of its being an Oriental invention, and of its having been thence imported into Europe; and, indeed, the military use of rockets in the armies of India ascends to a period beyond record.

Of the earliest period at which it was known in China, we have, in defect of their own evidence, only the testimony of Uffano, an Italian author, who affirms that not only gunpowder, but ordnance, was in use in that nation in the year 85 A. D.; and that cannon were, in his day, remaining from the most ancient times, in some of the maritime provinces, made both of iron and brass. Hence some writers presume, that the Chinese communicated the invention to the Indians; while it has also been said, but on no sufficient authority, that they themselves received it from Tartary;—a nation respecting which we know little or nothing, and in which we should not be inclined to look for an early acquaintance with the arts. This, however, refers to a date so late as 917; so that, if there is any dependence to be placed on the Indian and Chinese hypothesis, the Tartars must themselves have borrowed the invention from those to whom they are said to have lent it.

There is after this a long blank; and the first author on the subject that we have discovered is in 1249, twenty years before the date of Bacon's narrative. This is an Arabic writer, in the Escurial collection, who is translated by Casiri. His description is such, that it may apply both to rockets and to shells. In the former case, it only proves the knowledge of the detonating compound; the latter, were it proved, would show that they were also acquainted with the use of ordnance; although it is not impossible but that such projectiles might have been thrown by mechanical artillery.

As the invention of gunpowder has been popularly attributed to Bacon and to Schwartz, so the use of ordnance has been referred to the time of the field of Cressy, or 1346. To pass over the Chinese hypothesis on this part of the subject, we shall find that cannon was known at least as early as 1312. This we derive from the source quoted by Casiri; from Arabian writers who describe the use of ordnance in 1312 and in 1323; while, if Barbour is to be trusted, Edward III. was also provided with some pieces of artillery in 1327; and Pere Daniel asserts that cannon was known to the French in 1338. We need not carry this discussion lower; though, in favour of the Oriental origin of this invention, we would still remark, that artillery was much in use in the Mediterranean when it was still little used elsewhere; as by the Venetians against Genoa, in 1380, and by Alphonso XI. in his wars against the Moors.

Composition of Gunpowder.

The present composition of the Chinese corresponds so nearly with our own, that the difference is nearly insensible; but whether it had arrived at that degree of perfection in their ancient periods, we have no means of knowing. Neither can we judge of its nature and power as known to the Arabs. But, in our own country, it was very late in arriving at its present state of perfection; nor do the various proportions given by one of our earliest writers on the subject, argue much in favour of their chemical knowledge, or turn for experiments. Peter Whitehorne, who wrote in 1573, gives numerous proportions, without seeming well aware of their respective values; and, respecting some of them, it is easy to see that they were scarcely fit for squibs, much less for the purpose of projecting shot. Such is nitre, sulphur, charcoal, equal parts; while, in the very opposite extreme, we have nitre 12 parts, sulphur and charcoal, of each 3 parts; and, still worse, nitre 27 to 3 of the other two ingredients; or nitre, 48 parts, with 7 of sulphur and 3 of charcoal. Here, such as these compositions are, want of experience can scarcely be pleaded, as they are not better than those given by Nye, in 1380. In France also, the composition, at no very remote period, was nitre 50, sulphur 16, charcoal 34; from which it varied to, nitre 67, sulphur 13, charcoal 20, and to nitre 84, sulphur 8, charcoal 8: these differences being supposed necessary for the larger cannon, and the smaller progressively; the last being their musket powder.

But as we cannot afford space to describe the gradual progress of improvement in the composition of gunpowder, we shall now state the proportions at present in use in different nations. They do not materially differ from each other, although it is unquestionable that they are not all of equal power.

Gunpowder.

	Nitre.	Sulphur.	Charcoal.
China,	$75\frac{1}{2}$	10	$14\frac{1}{2}$
Italy,	76	$12\frac{1}{2}$	$12\frac{1}{2}$
Sweden,	75	9	16
Russia,	70	$11\frac{1}{2}$	$18\frac{1}{2}$
Poland,	80	8	12
Berne,	76	10	14
France, three proportions, according to Guyton Morveau, and the Committee of Public Safety, A	76	9	15
B	77	7	17
C	80	5	15
Do. according to Chaptal,	77	9	14
Do. at present in use: three kinds, Ordnance,	75	$12\frac{1}{2}$	$12\frac{1}{2}$
Small Arms,	78	10	12
Mining,	65	20	15
Do. recommended by Proust,	78	9	13
Piedmont, according to Antoni,	$71\frac{3}{7}$	$14\frac{2}{7}$	$14\frac{2}{7}$
Holland,	70	14	14
England, Government,	75	10	15

The proportions in the *commercial* gunpowder of England vary indefinitely, according to the views of the manufacturer respecting the markets, the price, and other matters. Cheapness being the leading object where it is only made for sale, and the nitre being the only expensive article, the proportion of this is diminished, and those of the other two ingredients increased. The worst is made for the Guinea trade, and, if we are not misinformed, that for the Canada trade is nearly as bad, while the next upwards in the scale is that sold to Turkey. We have never met any specimen in which there was less than 62 of nitre; but have reason to believe that some of the inferior kinds do not contain more than 50. For the use of miners it also is made with a low proportion of nitre; producing advantages in mining not intended by the makers, whose only object was to manufacture a cheap article. But the proportions of all the commercial powders are very inconstant, even when furnished *bona fide* to government, as it is impossible to prevent the workmen from purloining the nitre, and replacing it with the cheapest ingredients.

It is not for want of experiments if greater uniformity has not been attained in these compositions, and if all adhere to their own. Baptista Porta was one of the first who made accurate investigations on this subject; and, as long ago as 1515, he fixed on the proportions now used in France. Beaumé, some time ago, fixed on 80 of nitre, 5 of sulphur, and 15 of charcoal; and the opinions of Morveau, Chaptal, and Proust, are displayed in the preceding table. It is easy to account for these differences of opinion, when we recollect the numerous accessary circumstances which modify or vitiate the results obtained from practice. With the very same power it is scarcely possible to procure uniform ones, as is well known to Artillerists: and hence, from practice alone, unless with an enormous number of trials, no certain conclusions can be drawn. It will, indeed, appear, that under various proportions, the effects may really be the same; because, as the force of powder depends partly on the quantity of gas generated, and partly on the heat to which it is raised, any deficiency on the one hand may be compensated by an increase on the other. Thus, as the greater quantity of gas is produced by the largest proportion of charcoal, the greater heat is caused by augmenting that of the sulphur. In all the trials that have been made in this country, no reason has been found for varying from the proportion 75 nitre, 10 sulphur, and 15 charcoal; and the same is used for arms of all calibres—the only difference for the respective arms being made in the sizes of the grains.

Gunpowder

It is proper, on this subject, to state, that while the explosive power depends fundamentally on the quantity of gas that is permanently generated, that gas is almost entirely produced by the combustion of the charcoal; the nitre being the cause of that combustion, and furnishing one part of the generated gas from its decomposed acid, as it does the other by converting the charcoal into carbonic acid. Were nothing else required, therefore, to produce the effect, the best powder would consist of nitre and charcoal alone; as the sulphur consumes a considerable part of the oxygen of the nitric acid, without adding any thing to the permanently elastic gas. But as there are two other important elements in this problem, namely, the rapidity of the inflammation and the heat, the sulphur becomes an indispensable ingredient; while, by expanding the gas at the moment of explosion, it more than compensates for the diminution of permanent bulk which it causes. Perhaps, on this compound view of the subject, M. Beaumé's composition is really the best, abstractedly considered; as the nitre is sufficient to burn the whole of the sulphur and the charcoal also, and as both the degree of heat and the quantity of gas seem to be best balanced for the intended effect. But a composition of this accurate nature requires equal accuracy of mixture and manufacture; and as that is scarcely attainable on the great scale, it is found better so to increase the sulphur and charcoal as to insure the total decomposition of the nitre, this being further an object of economy.

Sportsmen, as well as Artillerists, ought to know that the fouling of their barrels after firing is in a direct ratio of the weakness and badness of their powder; and this effect is most completely obviated by using M. Beaumé's, or any similar mixture. Not only does the feebleness of such powder prevent the barrel from being swept clean at the explosion, but as the foulness consists chiefly in a mixture of the carbonat and sulphat of potash with charcoal, that becomes necessarily greatest wherever the nitre is reduced in quantity for the purpose of introducing the cheaper ingredients. The analysis of powder, at least as far as that ingredient is concerned, is so easily made, that every one who feels an interest in his success as a sportsman, should examine what he uses; as the very worst mixture can be rendered beautiful to the eye by a minute grain and a high polish.

The British Government use but one proportion for all services. As far as artillery and mus-

ketry are concerned, we do not consider this as of much moment; or that any material object would be obtained by using different ones, proportioned to the respective calibres. But we consider that they commit a great error in adopting the same for the *mining* service; and that some of the failures caused in our wars, in attempting to blow up works or demolish bridges, have been produced by the very excellence of the powder,—by its too great strength, in short. To take the case of common blast-mining as a simple one, and to put the extreme case of all; if it be attempted to spring a rock by the powder of chlorade of potash, either the plug will be blown out, or a very narrow space round the mine will be broken. With the best musket or cannon powder the same effects, but in a less degree, follow. Here the miners' powder, which seldom contains as much as 60 *per cent.* of saltpetre, is effectual; and, what is more, it is rendered still more active by being damp from careless keeping, or from remaining some time in the mine before it is fired. Mathematicians will immediately see the solution of this apparent incongruity, by recollecting that the element of time is an ingredient in the problem. With too great a velocity the parts of the general mass nearest to the acting force are disintegrated; so that not only is the force expended in this act, but the gas thus escapes from the opening. With a power acting more slowly, the whole mass, or a much larger one at least than in the first case, is moved; and thus the rock is widely shaken, although not blown into the air. It will be found practically, that the further the fragments are dispersed, the less is the effect; and thus the mine which is most dangerous to the workmen, is also the least efficacious.

It is from this variation respecting the power of gunpowder, hitherto unattended to, from confounding impulse and pressure, to which at least it bears a certain relation, that so many different opinions have been entertained respecting the force of powder in particular cases. Hence also have arisen various projects for increasing its efficacy; among which quick-lime has been repeatedly recommended. In mining it does actually increase the effect, though not the force. It diminishes the force, on the contrary; and it is from that very cause that it is more effectual in mining or shaking a rock. The same object can be obtained by a mixture of sawdust; but it must also be remembered, that this will not happen unless good powder be used. Ordinary miners' powder will not often bear this kind of dilution. It is easy now to apply this principle to military mining, where the object is to produce as extensive a shock as possible. Mathematicians have calculated the globes of compression for certain charges; but it will be found that these will vary so much, according to the strength of the material, that the conclusions cannot be depended on. This is a very important problem, however; because the destruction of a work depends on the area of the base of the paraboloid, or whatever else the figure is, which the explosion produces. We dare not, however, enter further on this subject, as it would lead us beyond our limits.

On the Choice and Examination of the Materials.

Nitre, as it is imported from India, whence all that is used in this country is procured, is mixed with much dirt and with some salts, consisting chiefly of the nitrats and muriats of lime, and of muriat of potash. As the deliquescent salts, in particular, are extremely injurious, from their property of attracting moisture, it is most important that the nitre to be used in gunpowder should be thoroughly refined. For this purpose rain water ought to be used if possible, and if not, such river or other waters as are found, on trial by the appropriate tests, to contain the least quantity of saline matters. The nitre is first boiled, and the grosser impurities separated by filtering through hempen bags, after which it is crystallized. After draining, one washing is sufficient to render the first crystallization sufficiently pure; but the subsequent ones require repeated solution and crystallization before all the foreign salts can be separated. We need not, however, dwell on this subject, and shall only add, that no nitre ought to be used unless it will stand the tests of nitrat of silver and of carbonat of potash, without exhibiting a precipitate.

It is held necessary that the nitre should be thoroughly dried; and, accordingly, much unnecessary labour is bestowed on this object, since it must be moistened in the mill when the composition is submitted to the rollers. The only real use in drying it is to enable the workman more easily to allot the true weight, which might equally well be done by an average and an experiment. We should scarcely have noticed this, but that the French manufacturers boast much of the superiority which they derive from reducing the nitre to minute crystals, by agitating the solution. In the royal mills it is further the practice to fuse the nitre into large cakes. By this method it is speedily dried, easily stored away, and protected from depredation. These advantages are held to be sufficient to compensate the expence; but it ought to be remembered that there is a degree of hazard in the process; as, if the salt should be overheated, it might be so far decomposed as to have a portion of potash united with it.

Sulphur, as it is received from Sicily, the great emporium of this commodity, is mixed with a considerable proportion of lime, while a portion of it is also combined with that substance, forming calcareous hepar, or sulphuret of lime. From this and the grosser accidental matters it is purified by melting; the sulphuret and the earth subsiding to the bottom of the mould, so as to admit of being mechanically separated. This residue, yielding no more pure sulphur by that process, is afterwards submitted to distillation. When the sublimed material is to be used, it requires previous washing, till it is entirely freed from the sulphuric acid adhering to it, and it may be tested for this purpose by means of the muriat of barytes. The fused sulphur, if doubted of, may be submitted to combustion, and the residue noted; but a little deficiency in the purity of this ingredient is of no moment.

With respect to the charcoal, there is considerably more nicety required than is generally imagined. The soft woods have been preferred from time immemorial; since even in the receipt of Magnus Græcus, formerly quoted, the willow is mentioned. The poplar and many others have been used abroad, but in this country those commonly adopted are the

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white willow and the alder. Even among these soft woods there is a considerable difference, as our own experiments have shown; and in them it was proved that the greatest explosive power, *cæteris paribus*, was produced by the wood of the *Rhamnus frangula*, commonly called black dogwood, as we shall show more particularly hereafter. The hard woods are invariably rejected, and with justice; though the reasons for this practice, which are derived from the presence of salts in these, are not the causes of their inferiority, certainly not the only ones. It is nevertheless true, that no wood which contains carbonat of potash, or other deliquescent salts, is fit for the purpose, and for the most obvious reasons; and this is the case in the oak, elm, fir, and other trees. But there is another reason for the badness of these kinds of charcoal, the cause of which is not so obvious, although it is evidently connected with their hardness. To us it appears to depend on the small proportion of hydrogen combined with the carbon in these charcoals, compared to that which exists in the produce of the softer woods. Even these can be reduced to the same state by overheating. Thus the hydrogen is dissipated, and the charcoal becomes so hard as to scratch steel, in which case, however obtained, it is always unfit for powder.

As this subject is yet obscure, from our imperfect acquaintance with the true nature of charcoal, and with the modifications of which it is susceptible, it becomes necessary to have recourse to experiment, for the purpose of determining, at any rate, the proximate cause of this difference in the explosive powers of the several kinds. Various trials have accordingly been made, as well by ourselves as by the French chemists; and, for brevity's sake, we add the most important results in the subjoined table. We are not informed of the process which was adopted by the French for measuring the gas; but in our own, we had recourse to the pneumatic apparatus, using it in the manner which is described in another part of this article for collecting the total produce of the combustion of gunpowder. The mixture, in the French experiments, consisted uniformly of 60 parts of nitre, and 12 of the charcoal submitted to trial. In our own they were varied, and the results taken from those in which the combustion of the charcoal was completed, and the quantity of gas greatest. As no more nitrous acid could be decomposed than there was coal present to burn the oxygen, it is plain that in these the results are correct.

		Prop. Parts. Gas.	Solid Residue.
French	Hemp stalks - -	62	12
	Asphodel - -	62	20
	Vine - -	64	20
	Peartalks - -	62	21
	Fir - -	66	30
	Spindle tree (*Euonymus Europeus*) - -	66	28
	Chesnut - -	66	36
	Hazel - -	66	33
	Lamp black - -	54	44
	Coak - -	54	45
	Filbert - -	72	30

These results are such as to prove that there are important differences in the produce of gas; but, with regard to practice, they are of very little value, as few of the substances submitted to trial could be used. To admit of comparison between our own experiments and these, we shall reduce our proportions to the same standard, by taking our scale from the filbert at 72. We neglect the residue, knowing that it proves nothing, as the results are uncertain, in consequence of the irregular absorption of water, and partly from the impossibility of collecting the solid and the gaseous matters both from one charge.

	Gas.
Filbert - - -	72
Oak - -	61, 63
Mahogany - -	58
Elm - - -	62
Willow, *Salix alba* - -	76, 78
Alder - -	74, 76
Black dogwood, *Rhamnus frangula*	80, 82, 84
Oak bark - -	58
Animal charcoal - -	50, 46, 42, 40
Coak - -	52, 48
Lamp black - -	54, 52
Oak charcoal overheated -	54, 56
Willow do. - -	59, 64, 66

The various results, and some others which we have thought it unnecessary to record, may, in a certain degree, depend on inaccuracies in the experiment; but in the greater number they arise from real differences in the charcoals from the same substance, produced, as we before insinuated, by overheating. This is apparent in the two cases above cited of oak and willow; but in some trials, the differences were even greater. Coak and animal charcoal are particularly liable to vary.

It is evident from the preceding table that the best charcoal for gunpowder must stand in the following order: Black dogwood, willow, alder, filbert. From the French tables, in which we do not, however, place much confidence, we may add, consecutively, hazel, and the spindle tree; but our own trials raise these to 70 at least, in the scale. Such, at present, are the results of these trials as to the best charcoal; but we are by no means satisfied that we have yet found out the best wood for this purpose. The experiments are laborious; yet we think the subject deserving of more attention than has yet been bestowed on it. With respect to coak and animal coal, they stand very low in the scale, as the overhardened wood-coals do; and, in all cases, there is a direct relation between the produce of gas and the facility of combustion under ordinary circumstances.

To satisfy ourselves by trials of a more direct nature, and more applicable to practice, we chose a method derived from the flight of rockets, as less liable to disturbance from collateral causes than any practice with pieces of ordnance. The rockets were of compound dimensions, and were all made with the same proportions and driven by the same hand, so as to ensure all possible uniformity, the only variation being in the nature of the charcoal. The vertical

 elevations were taken by two quadrants at the same time, and all the flights that deviated from the perpendicular rejected. The mean vertical ascent of a great number of those, made with willow, alder, and dogwood, was 480 yards; but between these three coals, the differences were so great as to give various results, which may be represented by the following numbers:

Dogwood,	515, 550, 525
Willow,	470, 480, 490
Alder,	455, 460, 470

Greater accuracy is not attainable in this way, as may easily be conceived by those who know by how many collateral circumstances a rocket is influenced; but these trials are quite sufficient to justify the general inference made from the experiments in the pneumatic apparatus.

It has been held that the charcoal for gunpowder ought to be made in cylinders or retorts by distillation; and this expensive process is consequently universally adopted. It is doubtful if this is not a mistake of the *causa pro non causa*. Pit charcoal being made in coppice woods, is always the produce of oak, and it is probable that this wood, if charred in close vessels, would be even worse than it is now. There is more danger of overheating in the retort than in the pit, while the wood is not better burned; and hence, by a careless management of the process, even the charcoal of willow or alder may be rendered as bad as that of oak. Considering these various circumstances, charcoal requires to be submitted to three tests. It ought to act, as little as possible, mechanically, even on copper; it ought to exhibit no salts on being treated with boiling distilled water and tested; and it ought to be thoroughly burnt. The best test of this latter circumstance is its giving out no smoke when heated.

A new and economical method of distilling charcoal has recently been invented by Sir William Congreve. Subsequently, but without any knowledge of what had been done, as we understand, the same process was suggested in America by Dr Bollman, to whom we are indebted for the present cheap method of purifying pyrolignous acid, and rendering it a substitute for common vinegar. In this beautiful process the retorts or cylinders are ranged in a row, a gas pipe from each being conducted to the bottom of the next in succession. By means of a fire under the first alone, the distillation of the whole may be conducted together; the gas which issues from that one being sufficient to char the next, and so on in succession to the end of the chain. The acid is collected in this case, as in others, by means of a separate pipe arising from a lower point in the retort.

Before we dismiss this very important and somewhat neglected department of the gunpowder manufactory, we must point out a circumstance with respect to charcoal, that requires an attention which it has never yet experienced. This is the property which it possesses of absorbing and retaining water, and which we have ascertained to be different in the different kinds of wood; although we have had no opportunity of investigating fully that which is here recommended to the attention of powder manufacturers.

It is from this hygrometric power that gunpowder attracts moisture, even when the nitre has been perfectly purified: a circumstance which materially interferes with its rapidity of inflammation, and, consequently, with its strength. But as the various hygrometric powers of different charcoals have never yet been properly examined, we can communicate no information on this subject which is worth recording.

On the Manufacture of Gunpowder.

Grinding.

The first part of the process consists in pulverizing all the ingredients separately, after which, they are weighed and mixed in a general and rude manner before being submitted to the mill. In France, and in some other countries, a pestle engine is used, or a stamping-mill; but it is subject to more hazard and inconveniences than the grinding mill which is adopted in this country. This is formed on the model of the common bark mill, and with two rollers at different distances from the axis, so as to cover the whole bed. The weight of each roller is commonly about three tons, and they are generally made of limestone, although iron cylinders have been adopted in some works. The bed, which is surrounded by a wooden margin, is of the same materials, and the whole house is built of slight framed wood, to diminish the evils that might arise from a casual explosion. A wooden rake follows the rollers for the purpose of bringing the mixture under the cylinder; and the motion is communicated, either by water or by the power of horses.

The mixture being distributed on the stone, to the amount of 40 or 50 lbs. is moistened with distilled or rain water, but so as not to be wetted. It is barely sufficient to prevent the dust from flying. According to the velocity, the grinding is perfected in a space of time varying from three to seven hours, and it depends on the inspector to determine by trial for each velocity when the mixture is perfect. After that, time is a sufficient measure. The removal of the mill cake, as it is called, requires caution, as it is commonly at this time that the explosions take place. These, indeed, will generally be produced if the bed and cylinder should come into contact while they are moved round slowly, to enable the materials to be taken out; the friction, under so great a weight, even of the purest limestones, or of iron, being sufficient to inflame gunpowder. To prevent this risk, a thick piece of hide is carried before the cylinder as the powder is removed, and by this plan the contact is prevented.

Pressing, Granulating, and Drying.

The mill cake thus completed is gunpowder, and may be granulated. But it is yet not so firm as it can be rendered by further pressure; and that property is very essential to its durability in travelling. For this reason, it is further condensed by pressure, either in the common screw-press used by packers, or by means of Bramah's hydraulic engine. Thus it becomes indurated to a hardness equal to

that of many stones, and its specific gravity is also increased. In the press, also, it is divided into cakes of an inch or more in thickness, that it may be the more easily broken into pieces for the Granulating Engine.

This machine consists of a number of sieves made of strong vellum, perforated by punched holes, and supplied with top and bottom covers, like those used by druggists. A platform, to which a horizontal circular motion is communicated by machinery, receives a number of these which are fixed in it. The lumps of the press-cake are introduced into each of these, together with a block of lignum vitæ or other hard wood, shaped somewhat like a Dutch cheese. During the rotatory motion, the lumps become thus broken into smaller fragments, which fall through the holes, together with the dust, into the receptacle below.

It remains to separate the grains according to the sizes that are required; and for military purposes, these are three; one for large ordnance, another for musketry, and a third for pistols. The powder generally used by sportsmen is of a still finer grain than the last. The separation is performed by means of wire gauze, or strong silk gauze, of different apertures; the sieves being commonly cylindrical and turned by the machinery. At the same time the dust is separated, and afterwards returned to the press.

The last operation is known by the name of Glazing, a term literally true in the case of sportsmen's shooting powder. But the real object of this operation is to take off all those acute angles from the grains, which would otherwise be ground off in travelling, and thus produce great inconveniences, by introducing dust into the casks. This process is performed, by causing the separate classes of grains to revolve in cylinders so constructed as only to let the dust through; and the mutual friction of the grains produces the desired effect. When it is required to give the powder a brilliant surface, as is the case with fine sportsmen's powder, the cylinder is lined with a woollen cloth; and sometimes, if a high polished gloss is desired, some black lead is introduced into it. But these are matters of mere ornament.

Although the powder thus completed appears dry to the feel as well as to the sight, it contains a considerable quantity of water. This must be separated by drying. In hot climates, exposure to the sun is sufficient, but in most cases, artificial heat is required. In France, a complex process was adopted by passing heated and dry air through a closed chamber, with the intention of diminishing the risk of explosion; but, with any moderate degree of care, it may be done in any manner. In some of the older works, the stove in use was a closed room with air holes above, heated by means of an iron cupola or large pot, to which a fire was applied outside of the building; the temperature being regulated by a thermometer fixed in the door and indicating the heat externally. In this room, the powder was exposed in flat trays round the circumference. Lately, the method by steam pipes has become generally adopted, and in this way, every possible security, real as well as imaginary, is obtained.

Analysis of Gunpowder.

It is often useful, and frequently indispensable, to analyse gunpowder. This process will, indeed, generally supersede the necessity of *proving* by the usual methods; as it is always certain that a specimen of gunpowder, well made, will produce the best proof. It is particularly convenient in the case of gunpowder purchased from merchants, or by contract; as, from the several causes which may easily be conjectured, such an article may be deficient in the quantity or in the quality of the saltpetre, or in both. It is useful, moreover, in the case of damaged powder, returned from military and naval service; as we can determine by these means, whether it has been wetted by rain or by sea water, or whether any portion of the nitre has been washed out. Powder thus damaged by fresh water only, and otherwise uninjured, may be committed to the mill and restored at a very trifling expence. If the saltpetre is diminished, it can thus also be restored; but, on the contrary, if the damage has been produced by sea water, it becomes necessary to destroy the powder for the purpose of extracting the nitre.

By washing the powder previously weighed in a filtre, with hot distilled water, the nitre is dissolved, and admits of being crystallized and weighed. The tests formerly mentioned, namely, nitrat of mercury and carbonat of potash, may then be used to determine its purity. Thus it may be ascertained whether, in a new sample, the nitre is in sufficient proportion, and whether it has been well purified, and in a damaged one, whether the injury has arisen from fresh or from salt water. It only remains to examine the proportions of the charcoal and sulphur; a task, however, which is less easy, but which is, at the same time, less necessary, as the manufacturers are under no great temptation to assume a wrong proportion of these, although the joint quantity of the whole may be in excess. This mixture, being dried and weighed, must be exposed to a moderate heat, as long as any sulphur can be sublimed. But, as the last portions are inseparable in this manner, it is necessary at length to have recourse to other means. Among those that have been tried, there is none more convenient than boiling, in a solution of pure alkali, by which a sulphuret is formed, and the weight of the dried charcoal thus completes the analysis.

Analysis of Gunpowder after Explosion.

To a certain extent, at least, an analysis of gunpowder, after explosion, is necessary for the purpose of procuring data whence its force may, *a priori*, be calculated. The rest is only matter of curiosity, and we have borrowed the determination from the experiments of the late Mr Cruikshank, a name known to chemists as that of the discoverer of carbonic oxide. As far as this analysis may differ from that of others, it must be recollected that the separation of mixed gases is not a very easy problem. The mere collection of the total gaseous products is easy; and had the same method been followed by Robins and others, less difficulty would have been found in their computations. Had Count Rumford,

and a numerous party of speculators on this subject, adopted so simple an expedient, they would not have had recourse to the expansive force of steam, or of the air contained within the charge, for an explanation of the cause and nature of the force.

By ramming 100 grains of powder into a narrow metallic tube, furnished with a long handle, it is easily caused to burn under water; as the combustion is slow and safe when it is thus condensed; and this quantity is sufficient for any purpose of experiment. The tube being plunged under the water, with its mouth downwards under the bell-glass of the pneumatic apparatus, the powder may be lighted without any loss. This is done by introducing, into that part of the tube above the charge, which is purposely left empty, a crooked wire heated to redness. After the hot wire and the tube in this position are immersed under the bell, the former is brought into contact with the charge. To prevent the water from absorbing any portion of the carbonic acid, sulphuric acid may be added to it, as well as many other matters too obvious to mention; or else it may be heated. Thus the gaseous product may be collected and examined at leisure, by the means which chemistry furnishes, and which our limits will not permit us to detail.

To collect the solid product, it is most convenient to use a glass vessel, on account of the certainty of obtaining the produce, which is, in great part, carried up in smoke, and adheres to the receptacle in which the powder is burnt. But we need not describe the numerous modes in which this object can be attained; only adding, that to diminish the hazard, the powder for this purpose may be wetted without affecting the results.

The following statement, then, contains the gaseous produce of 100 grains, made of the proportions 75 nitre, 10 sulphur, 115 charcoal; the measure and weight being both included. The temperature is reduced to 65, and the barometric pressure to 29.5.

The total gaseous produce measured 91 cubic inches, and the total weight 50 grains. Thus, about half the weight of the powder becomes converted into gas, and the remainder forms the solid produce:

	Grains.	Inches.
Azote - - - - -	13.24	42
Carbonic acid - - -	28.77	30
Carburetted hydrogen -	2.70	9
Nitrous gas - - -	3.25	6
Sulphuretted hydrogen - -	2.03	4
	49.99	91

The solid produce, however, appears in excess; possibly from being imperfectly dried: or else from some other unnoticed errors in the experiment. It is as follows:

	Grains.
Subcarbonat of potash -	40
Sulphat of potash -	11
Charcoal - - -	3
Sulphur - - -	0.5
	54.5

It is not difficult to account for these various products, and it is evident that the carbonic acid and the azote are the principal causes of the explosion. The decomposition of the acid, and the combustion of the charcoal, form the basis of the elastic force. It may be imagined that the hydrogen is the produce of contained water; but we consider that it is principally derived from the charcoal and from the sulphur. The two combinations which it forms are such as might be expected, and the nitrous gas requires no remark. Respecting the solid produce, the produce of the subcarbonat and sulphat of potash is a matter of course; and it is only necessary to point out the excess; of charcoal principally, of sulphur slightly. It is evident that more nitre would be required to consume them; but, as we formerly remarked, it is held expedient that there should be an excess in this way rather than in the other. We need not, however, dwell longer on this analysis; since, as far as the effects of gunpowder are concerned, it is the quantity, not the quality, of the produce that is an object of interest.

On the Sizes and Forms of the Grains in Gunpowder.

The variety in the effects of gunpowder, arising from differences in the sizes and forms of the grains, has been an object of much inquiry. The conditions of the problem are somewhat complicated. Within certain limits, which gunpowder made of nitre cannot exceed, rapidity of inflammation is essential to the production of a full effect. Not to inquire into other causes, without this property, a part of the charge is rendered useless by being blown out unburnt; an accident not uncommon on ordinary occasions. This may also happen from the form of the piece and that of the charge: it will occur in a long charge or in a short piece; or, most of all, when both are united. Hence variations in the effect of gunpowder, that are independent of its quality, and which will render computations, founded on that circumstance alone, deceptive. As we have not room to dwell on this subject as it deserves, we must refer our readers to Robins, and others who have written on it.

Now, this rapidity of inflammation may be attained, in some measure, in two ways: by intense heat, and by facility of transmission of the flame. But if a charge is considerable, no intensity of heat can compensate for the absence of the second condition. To put an extreme case. If the eight pound battering charge of a 24 pounder were a single grain, it requires little thought to perceive that the shot would have quitted the gun before the charge was half burnt. Hence, granulation is as necessary for ensuring the full effect as it is for con-

venience: and thus, also, we are led to the cause of the bad consequences of hard ramming: a charge very thoroughly rammed, and lighted at the anterior end, would burn like a fuse or a squib; if lighted by a touch-hole, it will be blown out like a shot. Thus the rapidity of the inflammation is secured by multiplying as much as possible the intervals for the passage of the flame, or by diminishing the size of the grains. Yet there is a limit even to this; and as that can only be determined by experiment, it is from such trials that the grain for the smallest charges has been fixed. As the charge, however, increases in dimension, the volume of flame and the intensity of the heat produced admit of a grain of greater bulk, or one containing, in a given dimension, a smaller number of intervals. Much refinement on this subject being, however, unnecessary, one size is used for all ordnance; while an inferior size is made for muskets, and one still less for pistols: the powder manufactured for fowling pieces is also of the smallest size.

But there is a further element concerned in this question; and that is, the different specific gravities of the different sizes of powder, or, what is especially to the purpose here, the different spaces occupied by the different sizes. The same measure which contains 172 grains of the smallest, contains 180 of the medium, and 195 of the largest. If powder be measured instead of weighed, it is evident that there will be one-ninth more of the large than of the small grained in a given charge: if weighed, the larger will occupy about one-ninth less space. In either case the greater force will be excited by the large grained, presuming that the inflammation is perfect: when it is weighed, as is the correct practice, it will not be very difficult to calculate the difference; as the force of the expanding fluid is, in a certain inverse ratio, of the space in which it is confined.

To increase the rapidity of inflammation, the French have manufactured spherical powder. The details of the process are such as would exceed the limits allotted to this article; but the principle may be understood by saying, that it is similar to that used by confectioners in making comfits. Angular grains are rolled in machinery adapted to that purpose, in powder dust slightly moistened; and thus small globules are formed. This grain is less liable to wear in travelling, from the absence of angles; but it is, at the same time, more tender and less able to bear pressure than pressed powder. Nor do the French experiments, either by the eprouvettes or the tables of practice, prove its superiority; on the contrary, the average results of its comparison with ordinary powder are unfavourable; and this also was observed in our own trial. Hence, it has not been adopted in Britain.

Proving of Gunpowder.

To ascertain, by practical trials, the strength of gunpowder, is not merely a matter of curiosity, but of absolute necessity. As the force, in battering ordnance, and the range, in mortar and howitzer practice, is regulated by the quantity of the charge, it is obvious, that no regular practice in the field, or consistent results, will be obtained, unless the standard of strength in the powder is both known and invariable. This is particularly the case with mortar practice against small works or redoubts, or against the enemy's trenches; and with howitzer practice against moving columns in the field. An invariable standard is, unfortunately, impossible; but it is always something to approximate to it. In military arrangements, a proof is also requisite, for the most obvious reasons, when powder is purchased from merchant manufacturers; not only that a minimum standard of strength may be fixed, but that, as far as is possible, the various qualities furnished may be reduced by mixture to an uniform standard.

It is usual, in the *first* place, among the workmen, as well as the merchants, to form a judgment of the quality of gunpowder by the aspect and firmness of the grain; and the latter, indeed, is a quality which is indispensable, if it is to be exposed to much land carriage. The nicety of tact required for this is, however, only to be attained by practice; as in all other species of sampling. The moisture is judged of by weighing, and by subsequent drying and comparison. The quantity of this is a question of profit and loss in the purchase. But it is more important to ascertain its hygrometrical powers, by exposure to moisture after drying. That is the best which gains least weight by this operation; nor, in any case, should the absorption of water amount to $\frac{3}{4}$ *per cent.* It is also a common practice to try it by what is called *flashing*: but this only serves to show whether it has been thoroughly ground: if not, the charcoal will produce sparks.

The trial of force is made by eprouvettes of different constructions, or else by practice. The most common eprouvette is a short chamber, provided with a gun-lock, the orifice of which is closed by a cover, connected with a graduated and ratchet wheel and spring. The quantity of the wheel's revolution is the esteemed measure of the force. But often as this machine has been varied and improved, the results are so irregular, that it may fairly be considered as uselesss. Various other instruments for this purpose have been invented and tried; but, without figures, we could not render their constructions intelligible. Regnier's does not materially differ from the preceding in its principles; and the results are equally unsatisfactory. His hydrostatic one appears to be still worse. We may say the same of that described by Saint Remy, and of another recommended by the Chevalier D'Arcy; and, of the whole, we would remark that the leading fault is want of simplicity. In a case like the explosion of gunpowder, where so many disturbing forces are always at hand to vitiate the true results, we cannot be too careful in eliciting all unnecessary causes of disturbance. If there is any one class of machinery in which simplicity is indispensable, it is that which belongs to gunpowder, under any of its relations.

We, however, consider that, as an eprouvette, Dr Hutton's pendulum is as free from exception as any machine can be. The disturbing forces are nothing, or as little as possible; the charging and firing admits of great uniformity; and, on trial, the consistency of the results justifies the expectations

formed from its simplicity. In this pendulum, the barrel is fixed upon the bob, and the force of the gunpowder is therefore measured, not, as in Robins's, by the impulse of a shot, but by the recoil. The indication of the extremity of the arc of vibration is made by a hand continuous with the pendulum rod, which moves an index furnished with a spring sufficiently strong to retain it at that point of a graduated arc, where it was left by the movement of the hand. The barrel used for this purpose is an inch in diameter, and is charged with two ounces of powder put in loosely, without wadding or ball. In this, as in all other cases of eprouvettes, the standard of strength is arbitrary; and, for service, is assumed from the best average of gunpowder manufactured by Government. The goodness of particular specimens is estimated by their agreement, or otherwise, with this standard.

Notwithstanding, however, the apparent accuracy of this method, artillery officers, both in France and England, are not satisfied with it as a method of proving powder for service. It is, perhaps, right, that practical men should, in a matter of so much importance, rely only on such a method of proof as agrees best with the particular objects for which the material is intended. Yet it should also be recollected, that all Robins's conclusions respecting the force of gunpowder were drawn from experiments made on his Balistic pendulum, and that the much more accurate ones of Dr Hutton, on which we now rely, were the results of the practice with that pendulum which we have just described.

The method of proving, then, adopted both in France and England, consists in real practice from a mortar at short ranges. In France a mortar is used of which the diameter is 0,191 (metres), or nearly eight inches English, and that of the touch-hole somewhat less than two lines. The diameter of the ball is 0,1895 (metres), and the windage consequently is 0015. The weight of the ball is about 60 lbs. A troublesome verification of the diameter of the bore, of the vent, and of the shot, is made for each day's practice. The mortar is condemned when the diameter is enlarged to 0,192, or if that of the vent becomes 0005 more than it ought to be. A difference of windage, amounting to 0002 (metres) more than what is allowed, condemns the shot; or, as it may happen, the whole apparatus.

All these verifications are so tedious, and the wear of the mortar, the vent, and the shot, so rapid, that it becomes inconvenient or impossible to follow them so nicely in practice when there is much business. It is, therefore, found more convenient to make a standard trial for each day's proof, and to refer all the others to this one; instead of trying to preserve what becomes impossible in practice, an absolute and invariable range.

The English proof-mortar, therefore, nearly corresponds with the French, it being of the eight-inch calibre, and of brass. The shot is turned and polished so as to be true, and to have at the commencement the least practicable windage. During the progress of use, as the windage increases from the wear both of the bore and of the shot, the range becomes contracted; a circumstance which also follows from the enlargement of the vent; in consequence of which a greater proportion of the generated air escapes at that aperture. But, from the practice adopted with us, these variations are of no moment, till the range becomes contracted so as to render it expedient to replace the shot or the mortar, or both.

The quantity of powder that is used is four ounces, and the mortar being elevated to 45 degrees, the range is measured in each trial. If the standard range for the day is 225 yards, the powder that gives a range of only 200 is rejected. The chief precautions requisite to procure fair results in this comparative method, is to take care that the level of the platform and the elevation of the mortar are subject to no accidents; that the powder be fairly placed in the chamber; that the priming tube always reaches to the same depth within the charge; and that the mortar be brought to the same temperature at each experiment. For this purpose, it is to be cooled with water.

Musket powder is submitted to a different species of proof; founded on the same views of rendering the proof for each kind as nearly corresponding as possible with the purposes for which they are designed. A barrel fitted with a turned steel ball, and with as little windage as possible, is used for this purpose. The ball is discharged at the distance of a few yards only, against a compound butt, made of elm planks an inch thick, soaked in water, and separated at a short distance from each other. The extent of the penetration is the proof of the strength of the powder; and the trials in this case also are referred to a standard experiment made each day. Before concluding this subject, we must add, that trials are also made for the purpose of ascertaining the hygrometric property of the powder to be purchased or issued. This is done by exposing a quantity for a given time in a box perforated with holes, and in a damp room, and then submitting it to the same proof.

Powder from Oxymuriat of Potash.

To increase the strength of gunpowder has been a favourite project with inventors at all times; all of them forgetting that the same end can be attained, as far as it is attainable, by augmenting the charge; and that neither the one nor the other is practicable without an entire reformation of the whole system of artillery. Could the force of powder be increased one-half, for example, it would be necessary to condemn almost every gun in use; and not only every gun, but every carriage, breeching, ringbolt; nay, we might almost add, every ship in the service. And supposing a new species of ordnance invented to suit the new powder, it would require at least one-half as much more of weight in guns and mortars, the same in gun carriages; with additional strength in every object concerned about them. In the field, in the same manner, an increased number of horses would be required. This view presumes that the object is, what in fact it always has been with the herd of inventors on this subject, to gain additional force, or range. If the purpose is only that of being enabled to reduce the quantity, and thus diminish the bulk and trouble of transportation, it is so trifling an ob-

Gunpowder.

ject as scarcely to be worth attaining. With regard to the main intention, or that of gaining greater range and force, it is only necessary to say that the powder is already too strong for the artillery.

As soon as the oxymuriat of potash was known, it became obvious that it would not only answer the same purpose as nitre, but, from its more energetic action, produce a more rapid combustion. It was first proposed and made by Mons. Berthollet in 1786; but an accident having happened from it at Essone, by which many people lost their lives, it was abandoned. The proportions used were 80 oxymuriat, 5 sulphur, and 15 charcoal. Afterwards they attempted to make a modified compound by using only a proportion of it with the nitre; but after various trials of this kind, the whole project was abandoned.

We have repeated Berthollet's method at different times, and on a very large scale, without accidents; but we consider that the proportion of oxymuriat is too large,—that it is at least larger than is necessary. A better proportion appears to be 75 oxymuriat, 5 sulphur, 20 charcoal. As this compound is very easily exploded by friction, it is necessary to be very cautious throughout the whole process; particularly in the granulations; nor is it safe to make more than one pound at a time. Of course, it may be mixed in wooden mortars, as it requires no large apparatus.

The great objection to its use is the facility with which it is inflamed by friction, or by a hard blow. The expence, indeed, would alone be an insuperable one, were there no other; as the price of this salt is more than twenty times that of nitre. It also corrodes the barrels very quickly. In fowling-pieces it is however of use; being the detonating priming of Forsyth's and of Manton's gun-locks. We may add, that very good powder may be made from this salt and charcoal alone, in the proportion of 80 to 20; but the grain is not very compact, and it is subject to all the same faults as the first.

The action of this powder on the shot in a charge is very capricious, and far from intelligible. In the French trials, it was found to give ranges sometimes double, and sometimes triple those of common powder, using the same weights. In various trials made in this country, the ranges were double in a majority of comparisons, when moderate charges were used. But, by increasing the charges beyond this, the ranges, instead of increasing in the same ratio, began to contract; double the quantity producing but a moderate increase in the range, and a third proportion making an addition still less than the preceding. This, however, agrees with Robins's experiments on common gunpowder; and he has accounted for it by what he calls the triple resistance; proving, as he thinks, that whenever the initial velocity exceeds 1142 feet in the second, a vacuum is formed behind the shot, which, by increasing the resistance before it, speedily reduces the velocity to what it would have been with a smaller charge. We need say no more respecting a compound, the use of which is not likely to be ever extended beyond its present application to the detonating gun-locks.

Keeping and Restoration of Powder.

Powder for service, whether for sea or land, is kept in barrels, containing each one cwt. the size of which is nearly that of a ten gallon cask, and they are hooped with copper. As it is difficult to keep dry casks water-tight, as indeed it was not thought necessary that they should be so, much powder was always rendered useless on service by wet. Lately copper linings have been very properly introduced, and the casks are now water-tight. As great quantities of powder always have been, however, and always must be, returned unserviceable; it is an important object to be able to restore it, or render it useful in the most economical manner.

Sometimes the grain is merely adhering, and can be shaken loose again; and this effect is not unfrequent even in magazines on shore. Such powder, when dried by restoring, appears sufficiently perfect; but it will be found that it is increased in bulk, and has become spongy and tender. On examination by the magnifying glass, it will also be perceived that the nitre is partially separated. Powder which has once undergone this change is deteriorated, yet is still fit for all ordinary purposes. It is not strong enough, however, to bear travelling; and, should it be required for that purpose, it ought to be remilled and granulated over again.

When the casks have been opened on service, before being returned, it is necessary to examine carefully whether they do not contain nails, or other foreign matters; an accident not uncommon. In such a case it is unsafe to commit them to the mill, and they must be reserved for extraction. When the powder has been so wetted as to be near into lumps, it is first necessary to examine, by the test of nitrate of mercury, whether the damage has been done by fresh or salt water. If by the latter, it must also be sent to the extracting house. If it has been very thoroughly wetted, even by fresh water, it will often be found that some of the saltpetre has been washed away. In this case it must be analyzed, so far at least as to determine the proportion of saltpetre wanting, which must be added to it in the mill. In the process of extracting, nothing more is necessary than to boil the powder in pure water, and to filter the solution through thick woollen bags. The crystals are purified exactly as in the case of rough nitre. This is a wasteful process, however, and *in all cases where it is possible, remilling is to be preferred.*

On Accidental Explosions in Powder Manufactories.

This is a subject which deserves far more attention than it has yet experienced; and we can only regret that our researches do not enable us to add more to the present suspicions as to the causes, than the little which follows. That want of sufficient care is the general source of these disasters is, however, certain; as certain merchants' mills have been celebrated for them, while in others, as well as in those belonging to the Government, they have been extremely rare. Such accidents may take place in any part of the works; but they are most frequent, as well as less injurious, when they happen in the mills; as the quantity of powder in these never exceeds 50 lbs. It ought at least to be an invariable rule to remove each charge to the pressing house as soon as it is completed.

We already hinted at the cause of the explosions in the mills, when they happen at the time of removing the powder from beneath the stones. As stamping-mills are not used in this country, it may be thought superfluous to remark, that, in these cases, this accident sometimes happens from attempting to remove, by a mallet and chisel, the lumps of powder which adhere to the pestles. It is one of the inconveniences attached to that mode of grinding. But it is also proper to observe, that the mills are sometimes blown up while working; and, from some examinations which we have made, we have little doubt that this has arisen from fragments of the stones falling off, and being bruised together with the powder. We indeed consider metallic rollers as every way safer than stone ones; as they can only produce fire in case of friction in contact during the removal of the charge. If iron be held objectionable, it is easy to face them with a sheet of copper; but it is proper to recollect that, even thus, the chances of explosion from friction are not removed. It is a great mistake to suppose that the absolute hardness of any metal is indispensable to the production of explosion in gunpowder. A blow sufficiently powerful, or friction caused by sufficient weight and rapidity, will compensate for the absence of this, in very soft metals, as well as in many other substances, which do not readily give fire. Limestone we consider to be a very objectionable substance. Except that of Carrara, we know of none, either primary or secondary, that does not contain much silica; often, indeed, particles of quartz sand. In the secondary calcareous rocks it is universal; nor is even the finest white marble of Carrara always exempt; as is well known to statuaries. But the softness, even of the purest limestones, is no defence; as the friction between these is still more capable of setting fire to gunpowder than that of iron. The readiest way of putting these different substances to the test, is by experiments in fulminating silver (that of Howard): as the irritability of this substance enables us to ascertain the facts with a moderate and convenient force.

We know of no explosions in the stove, except in one noted instance, when it was pretty well ascertained to have been produced by a workman, who had determined on suicide in this manner. In the steam stove it can never happen from overheating; but as the floor must necessarily be dry when the workmen enter to remove the powder, instead of being wet, as it always is in the other houses, it requires additional care respecting the feet of the people employed. The only method that is quite safe, in all houses and magazines, is to oblige the workmen to labour barefooted. The heavy leather slippers in common use are far from safe; as, from not fitting well, they are frequently dragged along; in which way they may easily entangle particles of sand. It ought to be known to all powder makers, that the breaking of a fragment of quartz, or the sufficient friction of two grains between copper, or even wood, is capable of igniting gunpowder. This is more particularly the case when the finer charcoals are used; as it is this which is the susceptible ingredient.

Explosions in the pressing and granulating hous have happened much too often, nor have the causes been ascertained. As there is a considerable quantity of powder always present here, these are of a very serious nature. It would be proper that these two buildings should always be separated, and, in the usual way, by a work of earth. The old granulating houses are far from safe, as the cranks and other parts of the moving machinery are contained within the house, which is always filled with the dust of the powder. It is trusting too much to the attention of persons, whom practice renders habitually careless, to expect that they will always keep the parts oiled. It is easy to remedy this evil by entirely separating the working machinery from the granulating engine, which may be suspended and steadied by ropes, so as to avoid all chance of friction.

In the pressing house there seem to be two sources of danger, both of which may be obviated. It is easy for powder to become entangled among the threads of the screw, and the consequence of this must be obvious. This would be remedied by adopting Bramah's press. We also think that the sudden condensation of air entangled among the fragments in the pressing box may be sufficient to produce fire. Whether this be the case or not, it will always be prudent to make the first pressure as slowly as possible, that the air may be allowed to escape.

We have observed three other causes for accident, though neither of them belong properly to the manufacturing houses. It is, nevertheless, very important that they should be generally known. Charcoal, in certain cases, is liable to take fire spontaneously, and that even in the lump. This is a case exactly analogous to the pyrophorus of Homberg; and it unquestionably arises from the same cause, namely, the presence of a portion of potassium. It is an accident which, we imagine, can only happen to charcoal made in retorts; as, in the pit method, the potassium could scarcely be expected to escape combustion. The precautions hence requisite, respecting the stowage of charcoal, and the place of the distilling houses, must be evident. When in a state of powder, and under pressure, it also has been known to inflame; and, possibly, from the same cause.

We are not aware that it is usual to keep many waggons and powder-cart tilts about powder magazines, but we do know that this has happened, and with the effect of producing fire. It ought to be generally known, for many other reasons, that fresh painted canvass, stowed close, is subject to spontaneous combustion.

Lastly, it has frequently been observed that fire was struck in closing up the powder barrels, as well on board ships as in magazines—an accident which was supposed impossible, since both copper hoops and hammers are exclusively used. We at length discovered that this accident had arisen from using cast rivets, in the surface of which the sand of the mould had become entangled. Hence the obvious necessity of using none but forged copper rivets, and since the adoption of these in the Government stores, this accident has been unknown.

On the Force of Gunpowder when Fired.

It remains to inquire, whether there are any means, *a priori*, of determining the explosive force of gunpowder, and of discovering what that is or ought to be. Many calculations have been made on this subject, and some of them, we need scarcely say, are deserving of great regard, although by no means in accordance with each other. Many, on the contrary, proceed on principles, so often gratuitous or false, as to be entitled to no consideration. When we consider the reputation of some of the authors of these speculations, and the real knowledge of the true cause of explosion which were then in existence, the history of these opinions, and thus of the deduced results, are not a little curious.

Lemery, Wolf, Papin, and some others, considered that the cause of the explosion was to be sought in the rarefaction of air contained in the interstices of the powder; forgetting, that in a rocket, which can contain none, the production of air was sufficient to communicate and maintain a considerable velocity during the whole time of the combustion. John Bernouilli imagined that this air contributed an eighth part of the force only, and that the remainder arose from water contained in the saltpetre. Muschenbroek, Stahl, Beaumé, and Macquer, again, considered the whole effect as produced by the conversion of the water of the nitre into steam; an error quite unpardonable in the two last chemists, who ought to have known that nitre contained little or no water of crystallization; and still more so in Count Rumford, who has followed them in this theory. Lombard, attempting to improve on it, adds to the expansion of steam that of the nitric acid. The Abbe Nollet allows the water but a share in the explosion. But not to enumerate more of these hypotheses, we shall only mention further, that of those who have attributed the expansive force to the conversion of latent into free, or radiant caloric, as they have thought fit to term it.

It would have been much more easy and correct to have put this question to the test of experiment, when the real cause would have immediately appeared. It was sufficiently unpardonable, in the greater number of these persons, not to have inquired what had been done before them; since Boyle, Hales, Hawksbee, and others, were aware that the combustion of gunpowder produced a permanently elastic fluid; although their mode of obtaining it in an exhausted receiver was not a very accurate one. Hawksbee found that one grain of powder, when fired in vacuo, produced a cubic inch of a permanently elastic fluid, and that the same result was obtained in air. Hence, though not acquainted with modern chemistry so as to be aware of the nature of the generated gas, he knew well that it could not have arisen from the expansion either of air or water contained in the powder. The inaccuracy of Count Rumford's views, and the extraordinary results of his numerous and laborious experiments, exceed, however, all that has been done on this, or perhaps on any subject in modern experimental philosophy.

The history of opinions respecting the explosive force of gunpowder, and all alike pretending to be deduced from experiments, is scarcely less amusing than the hypotheses respecting the cause; although rendered much more marvellous by their extraordinary discrepancy. John Bernouilli considered the initial force as equal to 100 times the pressure of the atmosphere; while Daniel Bernouilli made it 10,000. Bracehus determines it at 450, D'Antone as lying between 1400 and 1900, and Ingenhouz at 2276. According to Dulacy it is 4000, by Amontons it is 5000, and by Lombard it is stated at 9215. After this there is a rapidly increasing estimate among other experimenters: Monsieur Le General de la Martilliere representing it at 43,600, Count Rumford at 54,750, and Monsieur Gay de Vernon, who outdoes all his competitors, stating it as making from 30,000 to 80,000.

Among the French, Gilot's experiments appear the only tolerably accurate ones; as he states the produce of 100 lb. of powder in gas to be 463 cubic feet. This, however, is considerably under the truth, at least in the present French powder, as well as in our own. Of course, this is not meant to represent the total force; but he has not given any statement of the increase of volume produced by the temperature on firing. The coincidence between Robins's and Gilot's results is, however, considerable; but the French philosopher is beyond the truth.

According to Robins, from experiments made in an exhausted receiver, the produce of gas from a given quantity of powder, bulk for bulk, is 236; or one cubic inch of powder produces 236 inches of elastic fluid at the mean temperature and pressure. If the powder be rammed into the smallest possible space, the produce is double, or 472 inches of air; as it may be condensed, by hard ramming, into half the space which it occupies when loose. But we must beware of assuming this as an element in the computation of the initial force, however true a representation it is of the fact, abstractedly considered. In practice, powder would produce no corresponding effect in this state, because the ball would have quitted the piece before it was half burnt. Now, Robins's experiments tally very nearly with our own, as formerly stated; the produce from rammed powder being about 520 on an average of trials, which, being reduced in the proper ratio for powder as it is fired, gives 260 instead of 236. It is not impossible but that our powder may have been superior to his.

Thus much for the permanent produce. But there is another important element required, before the expansive force of the powder at the time of firing can be determined, and the initial velocity calculated. This is the augmentation of bulk produced by the elevated temperature which results from the combustion. According to Robins, that is such as to render the pressure, or force of the generated fluid at the moment of explosion, equal to 1000 atmospheres. Dr Hutton, more justly, states this at 2000; a force far short of the imaginary ones which we have quoted above.

We should have proceeded to examine the experiments on which this determination was founded, and to compare the calculations with the results of

practice. But our limits warn us that we must draw this article to a close; and we shall, therefore, refer our readers to the writings of Robins, Euler, and Hutton, on this subject, as alone deserving of attention. Yet we cannot conclude, without suggesting the only method,—a method yet untried, by which the true force of the explosion may be discovered *a priori*; or, at least, the real bulk of any given quantity of the generated gas, at the moment of inflammation, may be ascertained. It is a heat which cannot be conjectured, and to which no true approximation has been made by any method yet used.

By firing the given charge of gunpowder under a given quantity of water or mercury, it is easy to measure the temperature to which it is raised. Hence, recurring to the difference of capacity for heat between either of these substances and the generated gas, to their relative quantities, and to the law for the expansion of gaseous fluids by heat, as determined by Gay Lussac, the problem may be solved, for that case at least; as we are fully sensible that no rule truly applicable to all cases can be established, when the numerous variations to which, in practice, the conditions are liable, are considered.

P. P. P.

LIFE PRESERVERS.

Although it too frequently happens, that an accident, which materially endangers the life of an individual, deprives him, in the mean time, of that presence of mind which alone would enable him to take proper measures for his safety; yet to have meditated, in an interval of leisure, upon the best method of proceeding in case of emergency, must tend greatly to diminish the embarrassment and confusion that commonly accompany the accident, even if it should not be thought necessary to provide any particular apparatus for the purpose of escaping the danger. There are also many ways in which those who are not immediately involved in the disaster may contribute to the preservation of life, whether actuated by interest, or by humanity only; and the modes of relief will, therefore, be naturally divided into the *internal* and the *external*, whether relating to *fires* or to *shipwrecks*.

Sect. I.—*Internal Fire Escapes.*

Whenever a family establishes itself in a residence not detached from others, it becomes of importance to ascertain what facilities the house affords for ascending to the roof, and for passing to those of the neighbouring houses. It is scarcely possible that a conflagration should extend at once to the contiguous houses on each side, before the inhabitants of the house in question have had time to escape. But in a detached house, if there are not two or more staircases remote from each other; and even in a house contiguous to others, when there is no facility of communicating by the roof, it becomes highly expedient to provide some *internal means* of escaping through the windows in case of fire; and to have *on every floor* a good strong rope, with a hook or a loop at the end, by which it may be fastened to a bedpost, so as to enable an active person to descend by its help out of the window, finding from time to time a partial footing in the inequalities of the wall. This process will be greatly facilitated by having the rope knotted at intervals of about a foot throughout its length; the knots being nearly as convenient as the blocks, or clips, that are sometimes made for the purpose of retarding the descent, by holding them, and regulating the friction by the pressure of the hand* (Plate CX. fig. 14); unless the clip be attached to a strong cross bar, on which a person may sit, while he regulates the position of the clip by its handles, and allows himself to descend with more or less velocity at pleasure. The arrangement for this purpose may be made by a roller, or pipe, sliding on the rope, and pushed down so as to open the handles of the clip and tighten its teeth, when the person holds by the roller and draws it down (Plate CX. fig. 13); and, on the contrary, the clip may be opened by pressing on the handles with the other hand, or with the thighs; or any other simple mode of regulating the clip may be adopted, provided that it be not liable to be misunderstood, or misapplied in a moment of confusion. After all, a rope ladder would perhaps be preferable, as not being liable to be deranged; it is often kept ready made in the shops; and in the absence of any other rope, a common bed cord will generally be found strong enough to support the weight even of a stout man; for a quarter inch rope may be safely trusted with two hundred weight, and ought, indeed, to support three times as much if new and good.

Sect. II.—*External Means of Escape from Fire.*

The external means to be employed in cases of conflagration must be provided by the managers of fire offices, or by other public officers; and every ingenious workman, whom they may employ, will be able, at his leisure, to devise such apparatus as he can the most conveniently execute, and to give it a full trial in the absence of all danger; it will, therefore, only be advisable that he should compare for himself the particular inventions which have been suggested for this purpose, and that he should choose from among them such as he thinks most likely to do him credit; and he may, indeed, very possibly find means of improving on any of them.

1. In Leupold's *Theatrum Machinarium* (Plate LIV. LV.) we find the representation of a chair calculated to be drawn up or down by means of pulleys.

* Emerson's *Mechanics*, fig. 228, 229; Leupold's *Theatrum Machinarium*, Plate LIV.

2. Mr Varcourt obtained, in 1761, the approbation of the Parisian Academy of Sciences for his invention of a hollow mast, fixed in a waggon, and supporting a stage, with the means of ascending and descending. (*Hist.* p. 158.) 3. In the beginning of the present century, a fire escape of Mr Audibert was approved by the Parisian Institute. (*M. Inst.* IV.) 4. A committee was also appointed for examining several similar inventions at the Lyceum of Arts, and a medal was awarded by it to Mr Daujon, for his apparatus, which consists of a platform carried on wheels, supported by three frames, with brass wires, on which boxes are made to slide up and down for the conveyance of persons or of furniture. (*Annales des Arts, Repertory* ii. I. p. 439.) 5. Mr Collins's invention of pipes raised by ropes, and affording a centre to a long lever, is described in the fourth volume of the *American Transactions*, and in the *Repertory*. (Vol. XV. p. 35.) 6. In the thirty first volume of the *Transactions of the Society of Arts* (for 1813, p. 244), we have an account of a fire escape invented by Mr Adam Young, for which he received a medal from the Society. It appears to constitute by far the most portable of ladders, consisting of cross bars or rounds, connected by ropes, and having their ends fitted together, so as to form a pole, which is readily elevated to the window; and the rounds being separated, and the hooks at the end properly fixed to the window frame, the whole forms itself into a very convenient ladder of a mixed structure. 7. The *thirty fourth* volume, for 1816 (p. 227), contains a description of Mr Braby's fire escape, consisting of a car made to slide on a strip of plank fixed to a pole, and governed by a rope, which is cased with iron, to protect it, in case of necessity, from the effect of the fire.

The modes of extinguishing fires are not precisely the objects of the present inquiry; but it deserves to be remarked, that the only rational principle on which the methods proposed have been founded, is that of cutting off the supply of air, either by a coat of water or steam, or by means of some chemical substance, capable of forming an impenetrable varnish, or glazing, on the surface of the combustible materials. A mixture of clay, with sulphate of iron and alum, has been proposed for this purpose, but its utility must obviously be extremely limited, and it must require to be applied with great address, so as to be brought into fusion exactly at the place where it is capable of protecting the substances not yet consumed.

Sect. III.—*Internal Means of Escape from Shipwreck.*

The means of escaping from shipwreck may be similarly divided into internal and external, or into the precautions to be taken by the ship's company, and the measures to be adopted by persons on shore. The internal means depend either on enabling the individuals to swim or float, or establishing a connexion with the shore by ropes; and of the former, we may first consider those which require no particular preparation before the occurrence of the accident that calls them into action, and which are therefore the most universally applicable.

Of such expedients the most effectual appear to be those which depend on the employment of empty water casks for assisting the ship's company to drift on shore. 1. A paper on the arrangement of water casks, to serve as floats in case of shipwreck, appears in the publications of the *Society* for the Improvement of *Naval Architecture*, dated in 1796. (Vol. II. i. p. 51.) 2. In 1818 Mr Grant of Bideford obtained a gold medal from the *Society of Arts*, for the invention of a life preserver, consisting of a 36 gallon cask, with some iron ballast fixed on a wooden bed, and lashed to the cask, and with ropes round it for the men to hold; and it was found that ten men were supported by it with convenience in tolerably smooth water, the bung of the cask being well secured by cork. (Vol. XXXVI. p. 63.) The ballast could be of very little use, and a cask simply tied round with a rope, like a common parcel, would probably answer the purpose equally well. It would, indeed, be prudent for every ship in a storm on a lee shore, to have a few of her casks well emptied and stopped, and tied in this manner, before the actual occurrence of imminent danger. 3. In the thirty seventh volume of the *Transactions of the Society* (p. 110), there is an account of Mr *Cook's* life raft, consisting of a square frame with canvas nailed across it, supported by a cask at each corner, for which the gold medal was voted to him. 4. It is followed by a description of Lieutenant *Rodger's life raft* (p. 112), which obtained a similar compliment. This raft has the advantage of requiring only such materials as are usually found on board of every ship; capstan bars, boat masts, yards, or any other spars of moderate dimensions, which are tied together so as to make a sort of waggon frame, with a large cask fixed on each side; it appears to afford a very convenient support to the men, but it can scarcely possess any great strength for resisting the force of the breakers.

Mr J. Bremner, a clergyman in the Orkneys, had received a medal from the Society in 1810, for his method of converting any ship's boat into a life boat, by putting into it three or four casks attached to the keel, which is to have a ring-bolt fixed in it for receiving the ropes by which the casks are fastened; he gives particular directions for making all the necessary arrangements in the twenty eighth volume of the *Transactions* (p. 134); he particularly advises that no use should be made of the natural buoyancy of the cavity of the boat, but that the bottom should be perforated without hesitation, wherever the hole would afford any additional facility for fixing a rope. Captain *Manby's* jolly boat fitted as a life boat, "at the expense of three pounds," seems to be comprehended among those preparations which are to be made previously to the voyage.

The buckling a soldier's canteen on his breast, as an assistance to enable him to float, belongs to these temporary expedients, which may occasionally be employed with advantage. Tying a hat in a pocket handkerchief, and holding it as a float, has been recommended by Mr Lawson in the *Philosophical Magazine* (Vol. XX. p. 362); he advises that the crown of the hat should be held downwards, and observes that a stick may be employed, to enable us to use two or four hats at once; but this method can only

be adopted when the accident occurs in very still water.

The first and most obvious *preparation* for enabling a person to float, is the learning to swim. It is well known that swimming is scarcely ever sufficient to enable a seaman to reach the land from a ship that has been wrecked, without some assistance; and many have certainly been drowned from depending too much on their own strength; but for a momentary support, and to afford courage and presence of mind to seek for other aid, there is no question but that the faculty of swimming possesses an inestimable advantage. A boy generally learns to swim by the help of his schoolfellows, better than by any general rules, and more agreeably than in a school of natation; but it may be of some use to observe, that the act of diving to the bottom and reascending, in tolerably shallow water, is much more easily performed by a beginner, than that of simply supporting himself on the surface; and when he has thus acquired the feeling of the immediate effect of his arms in propelling and sustaining him, he soon finds out the means of employing his feet in their assistance. The art of swimming has, however, been systematically treated by Bachstrom, *Kunst zu Schwimmen*, 8vo. Berl. 1742; by Thévenot, *Art de Nager*, Paris, 1711; and by Bernardi, *Arte Ragionata del Nuoto*, 2 vols. 4to. Naples, 1794.

It is easy to convince ourselves, by trials in a warm bath, without reference to Robertson's experiments (*Phil. Trans.* 1757), that a substance possessing a very small degree of buoyancy is sufficient to enable the human body to float without effort. In fact, when the chest is fully expanded, the thinnest and most bony person will commonly float in sea water; but the effort of keeping the chest expanded is as fatiguing as any other muscular exertion; and when the chest collapses, the fattest people may be in danger of sinking unless they have learned to swim. Sir William Hamilton, indeed, tells us that in 1783, "a woman of Scilla, four months gone with child, was swept into the sea by the wave" accompanying the earthquake, "and was taken up alive, floating on her back at some distance, nine hours after; she had been used to swim; her anxiety and suffering, however, had arrived at so great a pitch, that just at the time that the boat which took her up appeared, she was trying to force her head under water to put a period to her miserable existence."

In China a frame of bamboo surrounding the person is used for a float, and the lightness and strength of this substance must make it extremely proper for the purpose; sometimes also a gourd is tied to a child, to secure its floating in case of accident. The inflated goat skins, used from time immemorial by the Arabs, or the seal skins employed by the Chilians, have the disadvantage of being easily punctured by a rock or a spar; an objection which is also more or less applicable to all substances containing air; for example, to the air jackets described in Leupold's *Theatrum Pontificium*, published about 1724. A float of a semicircular form was recommended by Ozanam, the author of the *Recreations*; and Bachstrom, in his *Art of Swimming*, proposed to float a troop of cavalry by fixing cork to the saddles. The cork jacket of Gelacy is described in the *History of the Parisian Academy of Sciences for* 1757, and Lachapelle's *Scaphander*, which is considered an improvement on it, in the volume for 1765. In the year 1764, the attention of the British public was particularly called to the floating powers of cork, by some experiments which were made with cork jackets on the Thames, together with some comparative experiments on air jackets; and Dr Wilkinson, in the *Philosophical Transactions* for 1765, describes some experiments by which he ascertained that about a pound of cork was amply sufficient to enable a man of ordinary size and make to float without effort. It is almost superfluous to enumerate the multitude of trifling variations that have been made in the arrangements of cork jackets and air jackets, apparently for the purpose of exciting a momentary interest, though possibly from the best motives. Mr Bosquet advised a bag of cork shavings to be kept in readiness by each person: the *Seaman's Friend* was composed of two pieces of cork, united by straps; the *Collinetta* was a hollow vessel of copper, divided into cells; a "marine spencer" has been described by Mr Spencer, in the sixteenth volume of the *Philosophical Magazine*, consisting only of a number of old corks, arranged so as to form a girdle; and in 1806, Mr T. C. Daniell obtained a gold medal from the Society of Arts for the invention of an apparatus of water proof leather, surrounding the body, which, according to the testimonials he produced, had saved the lives of some persons who had been sailing in a pleasure boat on a river. In smooth water, it has been suggested that throwing a foot ball, with a small weight tied to it, to the person immersed, would often afford sufficient assistance; and with respect to floating, there is no doubt that any of the assistances which have been proposed would be sufficient, if they were at hand; but there is another object, to which it is necessary to attend, in cold, and even in temperate climates, that of supporting a temperature compatible with life and health, if the immersion is likely to be of long duration; and an additional provision of worsted stockings, jackets, and trowsers, will be almost as essential, in such cases, as the means of obtaining buoyancy.

For the second object which is desirable to a ship in distress, that of obtaining a safe communication with the shore, it has been usual of late years to rely principally on the humane exertions of persons who may be on the coast, and who may have made preparations for this purpose; and with this view, some instructions for properly co-operating in the measures to be adopted with Captain Manby's apparatus, have been liberally distributed to all ships when they received their papers from some of the British custom houses. There are, however, some simple expedients which may be adopted for this purpose by persons on board of the ship: for example, the making a kite with a pocket handkerchief stretched over a hoop, and causing it to carry a cord to the lee shore, by means of which a stronger line, and at last a hawser, may be drawn by persons standing on the beach. A line may also sometimes be carried on shore by a cask, allowed to drift before the wind; and a bag has been recommended to

Life Preservers.

be attached to such a cask or to a buoy, in order to act as a sail, and to insure its crossing the surf. Mr Cleghorn was also rewarded, in 1814, by the Society of Arts, for the invention of a buoyant line, having a heart of cork, to obviate the inconvenience which would arise from its sinking and being dragged on the stones under the breakers; but he observes, that in heavy storms there is generally a current along shore, which renders the method almost impracticable. (*Transactions,* XXXII. p. 181.) A Mr Wheatley assures us, in Captain Manby's *Essay,* that his own life, and that of eight other persons, were saved in 1791 by a lead line, which was carried on shore by a Newfoundland dog that he happened to have on board; when two good swimmers had been drowned in the attempt to swim on shore. It had occurred to Lieutenant Bell in 1791, that a rope might be thrown from a ship which had struck, by means of a mortar carrying a heavy shot, and upon the principle of the gun harpoon; and he showed the practicability of the suggestion by an actual experiment, in which a deep-sea line was carried to a distance of about 400 yards. (*Trans. Soc. Arts,* XXV. p. 136.) He recommended that every ship should be provided with a mortar capable of carrying such a shot, and observed, that it might be placed on a coil of rope to be fired, instead of a carriage. The line was to be coiled on handspikes, which were to be drawn out before the mortar was fired. In 1792 he received a premium of 50 guineas from the Society of Arts (*Transactions,* X. p. 204); and he obtained his promotion in the Ordnance as an acknowledgment of his merits. The shot was to weigh about 60 pounds or more, and the mortar five or six hundred weight. The experiments of the French artillery at Lafere were subsequent to those of Mr Bell, though they have sometimes been quoted as the first of the kind.

It has, however, generally been thought impracticable to manage a mortar with effect under the circumstances of actual shipwreck; and Mr Trengrouse has preferred a rocket, as more easily fired, and as having a smaller initial velocity than a shot, so that the rope would be less in danger of being broken by the impulse. He found that a rocket of 8 ounces carried a mackerel line 180 yards, and a pound rocket 212; and, in some experiments made under the inspection of the Society of Arts, a rocket, an inch and a quarter in diameter, carried a cord across the Serpentine River in Hyde Park. The musket is provided with a valve, to prevent the escape of the materials of the rocket, and it is to be fired with a little powder, without wadding. The whole apparatus is packed in a chest, containing from eight to twelve rockets, the musket, a life spencer, a chair, to traverse on a rope, a canvas bag, and a ball of wood to throw to a person swimming. Mr Trengrouse was complimented with a medal from the Society of Arts in 1820. (Vol. XXXVIII. p. 161.)

Sect. IV.—*External Means of Escape from Shipwreck.*

The means to be employed by persons on shore, in cases of shipwreck, depend either on projecting a line over the ship, or on the use of a life boat. Mr Bell had cursorily observed, that a line might be carried over a ship from the shore by means of his mortar; but for the actual execution of this proposal, in a variety of cases, we are indebted to the meritorious exertions of Captain G. W. Manby, whose apparatus, according to the report of a Committee of the House of Commons, dated in March 1810, appears "to be admirably adapted to its purpose, and to have been attended with the fullest success in almost every instance." In consequence of this report, Captain Manby was thought worthy of a Parliamentary reward; and he afterwards published a description of his inventions under the title of *An Essay on the Preservation of Shipwrecked Persons,* 8vo. London, 1812. He had previously received a gold medal from the Society of Arts in 1808. (*Transactions,* XXVI. p. 209.) His success makes it expedient to extract from his *Essay* a detailed description of the apparatus, and it will be easy to make it somewhat more intelligible by a slight alteration of the order of arrangement.

P. 21. "The method of affixing a rope to a shot, for the purpose of effecting communication, when projected from a piece of ordnance over a stranded vessel, was at length succeeded in, by introducing a jagged piece of iron, with an eye at the top, into a shell, and securing it by filling the hollow sphere with boiling lead; and in another way, by drilling a hole through a solid ball, and passing a piece of iron, with an eye to it, as before described, to tho bottom, where it should be well secured by rivetting." (Plate CX. fig. 24.)

"To produce the means of connecting a rope to a shot, and prevent its being burnt, and rendering it '*irresistible*' to the powerful inflammation of gunpowder, was the labour of infinite time, and the number of experiments to accomplish it is beyond all possible conception. Chains in every variety of form and great strength breaking, proved that it required not only an elastic, but a closer connected body. At length, some stout platted hide, woven extremely close to the eye of the shot, about two feet in length beyond the muzzle of the piece, and with a loop at the end to receive the rope, happily effected it." (Plate CX. fig. 15.)

"This method is certainly desirable, as the rope may, immediately [as] it is required, be affixed to the loop, and applied in service. The form of the platted hide may likewise be woven by twisting it in the manner that the lashes of whips or ropes are spun; there is another method, by passing the rope through a case of leather, taking the greatest care that it is so well secured at the eye of the shot, as to leave no room for the SLIGHTEST PLAY, as is represented by the following BARBED SHOT." (Plate CX. fig. 19.)

"When the crews of the distressed vessel are incapable of availing themselves of the benefits arising from communication, they having previously lashed themselves in the rigging to prevent being swept away by the sea, which is repeatedly breaking over them, and when, from long fatigue and the severity of the storm (on which occasions it too frequently occurs), they totally lose the use of their limbs, and are rendered incapable of assisting themselves in

the slightest degree—the advantages of this shot are, that, on its being projected over the vessel, and the people of the shore hauling it in, it firmly secures itself on some part of the wreck or rigging, by which a boat can be hauled to the relief of the distressed objects; and by the counterbarbs it is rendered impossible [that it should] give up its hold, or slip, while that part of the wreck remains to which it has secured itself.

"Among the many that have been saved by this shot, the following are testimonials of a few of the cases:—We, the crew of the brig Nancy, of Sunderland, do hereby certify, that we were on board the said vessel when she was stranded on the beach of Yarmouth, on Friday morning, the 15th of December 1809, and compelled to secure ourselves in the rigging to prevent being swept away, the sea running so high over the vessel. And we do further declare and certify, that Captain Manby, firing a rope with a hooked shot, securely holding on the wreck, enabled a boat to be hauled from the shore over the surf to our relief, otherwise we must inevitably have perished." This certificate is attested by six signatures.

P. 27.—"Facilitating communication is at all times of importance; but when the stranded vessel is in momentary danger of going to pieces, this point becomes a consideration of extreme urgency. I feel a persuasion that this particular service can only be carried into effect by a small and light piece of ordnance, the range of which is consequently very inconsiderable, when compared with that of a large and heavier piece, as it is weight alone that conveys the rope. In order, therefore, to increase the powers of a shot projected from a small mortar, its natural form must be varied, so as to give it additional 'preponderance.' The following shape, in the form of a pear, has been used with the greatest success, for by the increased weight, the shot's momentum and power over the line is in consequence considerably augmented in its range; and when made to fit the piece as close as possible, a great increase of velocity is likewise produced from that decrease of windage. (Plate CX. fig. 11.)

"Portability in the construction of a piece of ordnance (as just described) is the very essence of this service; and communication with the stranded vessel or wreck may be effected with a cord, by which cord a rope can be conveyed, and by that rope a hawser or cable sent to the distressed vessel; for this purpose the following was constructed." (Plate CX. fig. 18.)

P. 31.—"A person completely equipped with every necessary apparatus to effect communication with a vessel driven on a lee-shore . . . the horseman, fully equipped, travelled a mile and a half, the howitzer was dismounted, and the line projected 153 yards in six minutes.

"The application of a small piece of ordnance (Plate CX. fig. 21) likewise offers particular advantages, capable of being employed from a boat to go to the assistance of a vessel grounded on a bar when running for a harbour, the necessity of which repeatedly occurs, and was twice witnessed at Blakeney on the 10th of November 1810, when boats endeavoured to go to their relief, and were enabled to get out of the harbour on the ebb tide, within 20 yards of the vessel; but it was found impossible to approach them nearer. Had such boats been provided with a piece of this description, and the same firmly secured on a stout piece of plank, by the holes left at each corner of the iron bed, they might have projected a small rope, coiled in a crate or basket made to the form of the bow of the boat, and the persons in the boat, so provided, would not have remained the distressed spectators of the untimely end of their fellow creatures, without being able to afford them the smallest relief, although so little was then wanted for that desirable purpose."

"Although advantages have been pointed out in the use of these small mortars, it is necessary to be kept in remembrance, that they are produced for particular services, as the nature of the coast, and circumstances attending the distressed vessel, will direct what piece is best adapted to the undertaking. To enable the mind to form a judgment what can be effected by other pieces, the following are the minutes of experiments made with a five and half inch brass mortar, stating the quantity of powder used, and distance the ropes were projected against a strong wind, at the angle of 17 degrees (elevation): weight of the mortar and bed about three hundred.

Ounces of Powder.	Yards of inch & half rope.	Yards of deep sea line.
4	134	148
6	159	182
8	184	215
10	207	249
12	235	290
14	250	310

"With a short eight inch mortar, the weight of which and bed was supposed to be about seven hundred; the angles of elevation uncertain.

Ounces of Powder.	Yards of deep sea line.	Yards of two inch patent Sunderland rope, capable of hauling the largest boat from a beach.
32	439	—
32	479	—
32	—	336

P. 15.—"*Directions for using the apparatus.*—When the rope (which should be pliant and well stretched) is brought on the beach or cliff opposite to the stranded vessel, the most even spot, and free from projecting stones, should be selected to lay it on, and great care be taken that no two parts of it whatever overlay or even touch each other, nor must it be laid in longer lengths than of two yards. But to project a small line or cord, it will be necessary, if it is required, to contract the faker to half a yard at most, to avoid the jerk received at the end of each right line. The best method, with such a

description of cord, is to lay it on the ground in the most short and irregular windings, to relieve it from this powerful impulse. To prove the effect of the impulse on a rope, if it is faked in lengths of ten or fifteen yards, it will break each time, as it then becomes a most powerful pendulum. These precautions are absolutely necessary to the success of the service.

"The following has, after various trials, been found a certain method of laying the rope, and placing it into compartments. (*French Faking*, Plate CX. fig. 1.)

"A particular attention to this mode will never fail with a good rope, when the impediments are removed that might otherwise obstruct its rapid flight. Its advantages are, that it will allow the eye rapidly (yet correctly, *just before firing*, which is absolutely necessary) to pass over the different compartments, and at once discover if any fake has been displaced by the storm, or by any other casualty or accident come in contact with another part, which would destroy its application by the rope breaking.

"It may likewise be coiled in the manner used in the whale fishery, *whale lair* (Plate CX. fig. 8); and in the following method, *chain faking* (Plate CX. fig. 5).

"It is, however, necessary to add, that great attention is required in laying it agreeably to the two latter methods, arising not only from the arm being liable to get under certain parts of the rope, and thereby displace it, but from the great anxiety of mind natural on these occasions, where the lives of fellow creatures are literally dependent on the correctness with which the rope is laid; it is, therefore, extremely difficult, in a moment of agitation, to determine whether any overlay has taken place, an error that would infallibly destroy every endeavour, and occasion even the fate of those whose lives we might be exerting ourselves to preserve. Could persons in the performance of this service be always collected, the two latter methods would have a decided advantage over the first mode of faking, they being laid in a much less space of time.

"As all these methods of laying the rope occupy time to place it with the care necessary; and as it has repeatedly happened that vessels, very soon after grounding, have gone to pieces, and all hands perished, it was necessary to produce a method of arranging the rope, so that it could be immediately projected as soon as it arrived at the spot; and none proved so effectual as when brought ready laid in a basket." (Plate CX. fig. 23.)

"In this case, the rope should be most carefully laid in alternate tiers or fakes, no part of it overlaying, and it should be well secured down, that in travelling it be not displaced. But, above all things, no mistake must happen in PLACING THE BASKET PROPERLY. For example, that the end of the basket, from which the shot hangs in the above plate, should be previously marked, as it is here represented, and must be placed towards the sea or wreck, that the rope be delivered freely, and without any chance of entanglement. It will be scarcely necessary to add, there will be several tiers of the rope when laid. The utmost care and attention are required in laying the rope in tiers with strict regularity, to prevent entanglement.

P. 36.—"The next is the application of the mortar. If the wind is sidewise to the shore, it must be pointed sufficiently to windward to allow for the slack of the rope lighting on the object, as the rope will, of course, be considerably borne to leeward by the effect of a strong wind, and by its being laid at a low elevation, insures the rope falling against the weathermost part of the rigging. While this service is performing, great care should be taken to keep the mortar dry; nor should it be loaded until every thing is ready; when that is done, it should be primed; but as it would be impossible to do it with loose powder in a storm, a tube is constructed in the simplest manner of common writing paper (the outer edge being cemented with a little gum) in this form. (Plate CX. fig. 2.) It is filled with meal gunpowder, made into paste with spirit of wine; when in a state of drying, run a needle through the centre, and take care the hole is left open, for, on the tube being inflamed, a stream of fire darts through the aperture with such force as to perforate the cartridge. The mortar should then instantly be fired, and in order to lessen a difficulty that has often occurred in performing this service, a pistol may be used, having a tin box over the lock, to exclude the effect of wind or rain on the priming; and the muzzle being cut [obliquely], dilates the inflammation, so as to require but little exactness in the direction of the aim.

"We will suppose the communication to be secured, although it is scarcely necessary to offer any other assistance than that of a rope, as the inventive genius of a sailor will supply every thing else, yet I could expect the people on shore to get a boat ready for meeting the vessel when driven on a beach; it is the promptest and most certain method of relief, as well as the most easy to be accomplished, for by hauling her off with the rope projected, the boat's head is kept to the waves, and not only insures safety by rising to the surge, but prevents her upsetting."

Again, p. 59.—"When the rope attached to the shot (not having barbs to it) is fired over the vessel and lodges, let it be secured by those on board, and made fast to some firm part of the rigging or wreck that they may haul off a boat by it; but should there not be any boat, then haul on board by the projected rope a larger one, and a tailed block, through which a smaller rope is rove. Let the large rope be made fast at the mast head, between the cap and the top of one of the lower masts, and the tailed block a little distance below it; but, if the masts should have been cut or carried away, then it must be made fast to the loftiest remaining part of the wreck. When this is done, there will be supplied from the shore a cot, hammock, netting, basket, hoop, or any of the numerous resources of seamen, which will run on the larger rope, and be worked by the people on shore. If a cot be used, the men may be so securely fastened to it, as to preclude all possibility of falling out, and then be brought from the wreck, one by one, in perfect safety."

P. 47.—"While communication is gaining, three

stakes should be driven into the ground in a triangular position, so as to meet close at the heads to support each other. As soon as communication has been effected by the crew of the vessel, and they have secured the line attached to the shot, made fast to these stakes, and the crew will haul on board by it a large rope and a tailed block, through which a smaller rope is to be rove, both ends of which (the smaller rope) are to be kept on shore. When they have secured these on board, and the larger rope is rove through the rollers, let a gun tackle purchase be lashed to it, then lash the purchase to the stakes. By the means of the purchase, the larger rope may be kept at a fit degree of tension; for, if care be taken to slacken the purchase as the ship rolls out to sea, the danger of the rope being broken will be guarded against; and on the other hand, if the purchase be gathered in as the ship rolls toward the shore, the slackness of the rope, which would prevent the cot traversing as it ought to do, and plunge it in the water more than it otherwise would, will be avoided." (Plate CX. fig. 9.)

P. 59.—" Supposing neither boat nor cot apparatus at hand, first cast off the shot from the projected rope, and with a close hitch, thus (Plate CX. fig. 17), let it be put over the head and shoulders of the person to be saved, bringing it close under each arm, drawing it tight, OBSERVING PARTICULARLY THE KNOT IS ON THE BREASTBONE; for, by having the knot in that position, on the people of the shore hauling the person from the wreck, he will naturally be on his back, consequently, the face will be uppermost to seize every moment for respiration, after each surf has passed over the body. If circumstances compel recourse to this method, care must be taken to free the rope from any part of the wreck, and to jump clear away; but should there be more than one on board, each man should make himself fast in the same way, above four feet from the other, and join hands, all attending to the same directions."

P. 61.—" *For giving Relief to Vessels Stranded on a Lee shore in a Dark and Tempestuous Night.* It will be requisite, first, to devise the means of discovering precisely where the distressed vessel lies, when the crew are not able to make their situation known by luminous signals; secondly, to produce a method of laying the mortar for the object, with as much accuracy as in the light; thirdly, to render the flight of the rope perfectly distinguishable to those who project it, and to the crew on board of the vessel, so that they cannot fail of seeing on what part of the rigging it lodges, and consequently have no difficulty in securing it."

" To attain the first object, a hollow ball was made to the size of the piece, composed of layers of pasted cartridge paper of the thickness of half an inch, having a lid on the top to contain a fuze (Plate CX. fig. 3), and it was then filled with about fifty luminous balls of star composition, and a sufficient quantity of gunpowder to burst the ball and inflame the stars. The fuze fixed in the ball was graduated, to set fire to the bursting powder at the height of 300 yards. Through the head of the fuze were drilled holes, at equal [distances], to pass through them strands of quick match, to prevent the possibility from any accident of the match falling out, or from its not firing the fuze.

" On the stars being released they continued their splendour while falling, for near one minute, which allowed ample time to discover the situation of the distressed vessel.

" During the period of the light, a stand, with two upright sticks (painted white, to render them more discernible in the dark), was ready at hand, and pointed in a direct line to the vessel." (Plate CX. fig. 7.)

" A shell, affixed to the rope, having four holes in it, to receive a like number of fuzes (headed as before described), and filled with the fiercest and most glaring composition, which, when inflamed at the discharge of the piece, displayed so splendid an illumination of the rope, that its flight could not be mistaken." (Plate CX. fig. 22.)

P. 66.—" *To get a Boat from a Beach over the Surf.* The importance of going to the relief of ships in distress at a distance from the land, or for taking off pilots, was viewed as of the highest consequence by the Elder Brethren of the Trinity House, and offered to my particular attention by several distinguished characters. After numerous experiments to accomplish it in various ways, the mode following was most approved. About forty fathoms of two and a half inch rope, made fast to two moving anchors, was laid out parallel with the shore, at a distance beyond the sweep of the surf; to the centre of this rope was made fast a buoy of sufficient power to suspend the great rope, and prevent it from chaffing on the sand, rock, or stones, as well as embedding, a circumstance that has rendered it impossible, on a sandy or shingly coast, to heave out an anchor with a rope to it from the shore. As this service should be performed in fair weather (to be prepared for the storm), it may be regulated with the greatest exactness, and should take place at the top of high water, that the upper part of the buoy may be at the full stretch of its power, and only seen at that time. (Plate CX. fig. 10.)

" Should the shore be extremely flat, it will be desirable to place another set at a sufficient distance beyond the first, to ensure the operation of this method in any state of the tide."

P. 71.—" The royal mortar being brought to the spot, is to be pointed in the direction for the buoy, and should be laid at a very low elevation, but such as to insure the range; for the more it is depressed, the less slack of rope there will be from the parabola formed in the shot's flight; the basket with the rope ready laid (having a barbed shot to it) is to be placed in the front of the mortar; on its being fired, instantly haul the slack of the rope in, to prevent the effect produced on it by a strong tide. Which being done, let the remainder be gently hauled in to insure the shot's grappling with the great rope; when that is caught and hooked, a power will be acquired fully adequate to the service. (Plate CX. fig. 16.)

" As a cast-iron anchor appears particularly adapted to this method, and would be much cheaper than hammered, the following is a plan of one which the Honourable the Navy Board approved, and allowed

Life Preservers.

me to cast at their expense, for the purpose of making the experiment." (Plate CX. fig. 20.)

P. 43.—" When a vessel is in that extreme and perilous situation, driven under a rugged and inaccessible cliff, and in danger of going soon to pieces, the most prompt method I should suggest is, by lowering to the crew a rope with stiff loops spliced into it, at the distance of a foot and a half from each loop, of sufficient size to contain the foot, by which they can ascend as a ladder. (Plate CX. fig. 6.)

" This rope ladder is capable of being projected; and one of an inch and half rope was thrown from a mortar 194 yards. It might also, from the simplicity of its structure, be extremely useful in escaping from a house on fire. By making one end fast to the leg of a bed or a table, the person would come down from the window in safety, and with much less difficulty, and quicker than with the common rope ladder, which is heavier and more unwieldy. It has great advantages when employed in saving shipwrecked men in situations just described, when, from extreme cold, and almost benumbed limbs, it would be impossible for them to climb up a rock, or ascend it even by the aid of a common rope. The holds, thus spliced in, will support both hands and feet."

The Report of the Committee of the House of Commons contains also a paper of instructions for the managers of Captain Manby's apparatus on shore, which are somewhat more minute than the directions published in his Essay. For example, p. 13,

" If the wind be sideways to the shore, the mortar must be pointed sufficiently to windwards to allow for the slack of the rope lighting on the object, as the rope will, of course, be borne considerably to leeward by the effect of a strong wind."

" The distance your judgment decides the vessel to be from the shore, should regulate the charge of powder as stated in the scale,—taking just a sufficient quantity to clear the object; an attention to this will be more certain of your effecting communication, and guarding against the danger of the rope breaking, or any other circumstance that might prevent the successful performance of the service. The elevation of 15 degrees is to be preferred, particularly if the wind is sideways, pointing the mortar sufficiently to windward, as the rope would then fall against the weathermost part of the rigging of the stranded vessel."

" When a vessel is driven on shore in the night, you will flash gunpowder as often as convenient on your way; this will animate the crew, and denote to them you are coming to their assistance. On getting to the spot where you have reason to suspect the vessel lies, as you are not able to discover her from the extreme darkness, and if the people on board cannot [make known] their situation by luminous signals or noises (which they will be directed to make if possible), you will lay the mortar at a very high elevation, and fire a light ball."

" Just before you fire (the rope) it would be advisable to let off a blue light to put the crew on their guard, to look out, and be ready to secure the rope. The service can be performed with a carronade."

In p. 15, Ch. IV. we have a copy of Directions to persons on board vessels stranded on a lee shore, proposed to be delivered to the masters at the custom house. It is observed, that even snapping a pistol, when the powder is wet, may sometimes afford a signal visible on shore, from the sparks of the steel alone. The other parts of the directions will be easily supplied by those who understand the principles of the proposed mode of relief.

Life Boat.

The last description of the inventions to be considered with regard to the preservation of lives, in cases of shipwreck, is that of Life Boats which are of such a construction as to be incapable of sinking even when filled with water. The occasional adaptation of the common boats of the ship to such purposes, by means of empty casks, has been already considered. But the boats now in question are supposed to be kept on shore at proper stations, and manned by active persons, who are in the habit of exerting themselves for the relief of seamen in distress.

Mr Henry Greathead, of South Shields, received a gold medal and fifty guineas from the Society of Arts in 1802, and a Parliamentary reward of L. 1200, besides further remunerations from the Trinity House, and from Lloyd's Coffee-House, for his invention of a life boat, which is described in the *Transactions of the Society*, Vol. XX. p. 283. The length of this boat is thirty feet, its breadth ten, and its greatest depth about three, besides a general curvature which nearly doubles the depth, as reckoned from the ends; the convexity below being intended to give it a greater facility of turning, and a greater power of mounting on the waves without submersion of the bow, which would increase the resistance, though it would not sink the boat; the breadth is also continued further than usual fore and aft, in order to contribute to the same property. The gunwale projects some inches, and the sides below it are cased with pieces of cork, amounting in the whole to seven hundred weight, which are secured by plates of copper. There are ten short oars of fir, fixed on pins to the gunwales, and a longer oar for steering at each end, both ends of the boat being alike. It is painted white, in order to be more conspicuous, and a carriage is provided, for conveying it over land when required. The description is accompanied by documents of the preservation of two or three hundred men by the boats of South Shields and North Shields, which were built in 1789 and 1798 respectively.

Mr Christopher Wilson received a gold medal in 1807, for a life boat with air gunwales, which was tried at Newhaven, and was said to be lighter and more manageable than Mr Greathead's. (*Transactions*, XXV. 55.)

" Little is required," says Captain Manby, p. 73, " to establish the importance and advantages that will result from giving every boat the properties of a life boat, particularly when taken into consideration that it can be produced at a very trifling expense."

To illustrate the method of giving the properties of preservation to any boat, I have selected the representation of a man of war's jolly boat, fitted up

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Engraved by W.H.Lizars

to make experiments thereon, by permission of the Honourable Commissioners of the Navy Board. (Plate CX. fig. 25.)

"To give it buoyancy, empty casks were well lashed and secured in it. For the advantage of keeping it in an upright position, launching from a flat shore, beaching, and to resist upsetting, it had billage boards of equal depth with the keel, and when a good sized piece of iron or lead was let into, or made fast to the keel, if any accident did upset the boat, it immediately regained its original posture. A stout projecting rope, with swellings upon it to increase its elasticity, surrounded the gunwale, served as a fender, and prevented it being stoved in lowering down, or when driven in contact with the vessel it might be going to relieve.

"The boat thus described had the plug out, and was filled with water until it ran over the gunwale, when a crew of four, with myself, tried it in every way, and found from the buoyant property of the casks, it kept the boat so much above the water's edge, that it was rowed with the greatest ease, and was capable of performing any service required."

Mr J. Boyce, in 1814, obtained a medal for his life boat and safety buoy, consisting of hollow cylinders, made of canvas, painted and varnished, and connected with each other. It was tried on a river, and carried a man with safety (Vol. XXXII. p. 177); but surely it could not be trusted among breakers on a lee shore. In 1818, Mr Gabriel Bray obtained a silver medal for his invention of a boat filled with air boxes, under the seats and along the sides. (Vol. XXXV. p. 172.)

Captain Manby's proposal for throwing ropes from ship to ship in cases of accidents, may easily be understood from the methods which he employs for saving lives in shipwrecks. Mr Thomas Cook's *life buoy* is related to the same class of inventions; its object is to preserve the life of a person falling overboard in the night by means of a floating light; and it obtained him a gold medal from the Society of Arts in 1818. (*Transactions*, XXXVI. p. 121.) He observes that a ship may often have to run half a mile before she can get about, and lower a boat; so that it becomes highly desirable to afford a temporary support to the sufferer. The machine consists of two casks, with a pillar between them, carrying a composition of portfire, to be lighted by a lock when the accident happens, and to serve as a rendezvous to the man and the boat. He found that it might be lighted, and let down into the water in the short time of five seconds; being always kept suspended in a proper manner between the cabin windows at the stern of the ship. Mr Miller's safety poles for skaiters, and Mr Prior's mode of preventing accidents in descending mines, are mentioned in the *Transactions of the Society of Arts*, Vols. XXXII. and XXXVI.; but they do not require more particular notice on the present occasion.

A sketch of the expedients which have been recommended for the preservation of mariners, published in a work entitled. *Shipwrecks and Disasters at Sea* (3 vols. 8vo. Edinb. 1822, Vol. III p. 459), contains a few further historical details relating to some of the inventions which have been described.

(V. N.)

PRINCE OF WALES'S ISLAND, called also Pulo Pinang, or Betel Nut Island, an island situated off the west coast of the Malay peninsula, from which it is separated by a narrow strait, about two miles broad, which forms the harbour, and affords excellent anchorage for the largest ships. There is also an inner harbour, where ships may receive every kind of repair that can be performed without going into dock. The principal entrance into the harbour is from the north-west; but there is also a fine channel to the southward.

This island is of an irregular four-sided figure; the north side being the longest, and the south the shortest. It is near five leagues in length, and is seven or eight miles in breadth. Throughout the centre of the island there is a range of lofty hills, decreasing in magnitude as they approach the south; and from these flow numerous fine streams, which supply the island abundantly with water.

The soil of this island is various, generally a light black mould, mixed with gravel, clay, and in many parts sandy. The whole island had been for ages covered with an immense forest, from which originated a fine vegetable mould, formed by the decayed leaves, which, as the woods were cleared, and the surface exposed to the weather, in a considerable degree disappeared; but the soil in the interior is still equal to any sort of cultivation. These forests produce excellent timber for ship building, and supply masts of any dimensions; lower masts of one piece having been procured here for a 74 gun ship. Much of the north, and nearly the whole of the south and east sides of the island, are in a state of cultivation. The principal productions are pepper, betel-nut, betel-leaf, cocoa-nuts, coffee, sugar, paddy, ginger, yams, sweet potatoes, and a great variety of vegetables. The fruits are the mangosteen, rambosteen, pine apples, guavas, oranges, citrons, pomegranates, &c. The exotics raised here are cloves, nutmegs, cinnamon, pimento, kyapootee, colalava, and a number of other plants from the Moluccas and eastern isles. Pepper is the chief article of cultivation: the quantity raised in 1804 was calculated at two millions of pounds. The elastic gum vine (*Urceola elastica*) or American caout-chouc, is found in great plenty on Prince of Wales's Island. It is about the thickness of the arm, almost round, with a strong ash-coloured bark, much cracked and divided longitudinally, with points at small distances, that send out roots, but seldom branches. It creeps along the ground to the distance of more then 200 paces, and then ascends among the branches of high trees. The milky juice of the vine is drawn off by wounding the bark, or by cutting the vine in pieces. The best is procured from the oldest vines, which will yield two-thirds of their weight of gum. The chemical properties of this vegetable milk surprisingly resemble those of animal milk.

Prince of Wales's Island.

This island was originally granted to the East India Company by the King of Queda, at the request of Captain Francis Light, who had married his daughter. The Bengal government seeing the island so peculiarly adapted as a mercantile station for vessels from all the Malay ports, the Moluccas, Borneo, Celebes, and the Philippine islands, did not hesitate to accept the King of Queda's grant; conceiving that, by an establishment properly secured, the Bengal trade, with that of China, would be connected: and, from the conduct of the Dutch, it became necessary to have a port where the country ships might meet the eastern merchants, as well for the promotion of that valuable commerce, as to afford a windward station of refreshment and repair to the king's, the company's, and the country ships. A small detachment was accordingly sent from Calcutta, under the command of Captain Light, who took possession of the island in the name of his Britannic Majesty, and for the use of the East India Company, on the 12th of August 1786. He immediately commenced clearing the country, and began the construction of a small fort for the protection of the detachment against any attempts of the Malay powers, who might be instigated by the Dutch at Malacca, or induced, by the fickleness of their own disposition, to cut them off. Captain Light was authorized to receive such colonists as he might judge expedient; to allot such a portion of land to each family as circumstances would admit; and, as an encouragement to trade, the port was made free to all nations. In a very short space of time, numerous adventurers flocked to the settlement, some with the intention of remaining, others merely with a view of traffic. These finding a ready sale for their goods, and meeting with the merchandise they required in return, the commerce of the port rapidly increased: a town, called George Town, was marked out, and within the year there were upwards of sixty Chinese families living in it, besides great numbers of Malays, Buggesses, and other Eastern traders. The settlements continued in a progressive state of improvement, both in regard to its population and cultivation. In the year 1797, there were 6937 inhabitants on the island, exclusive of Europeans and the garrison; and in 1801, they had increased to 10,310, of which 1222 were slaves. In 1805, the inhabitants of all descriptions were estimated at 14,000, and have since been progressively increasing, and exhibit an uncommon diversity of races. Here are to be seen British, Dutch, Portuguese, Americans, Arabs, Parsees, Chinese, Chulias, Malays, Buggesses, Birmans, Siamese, Javanese, &c. &c. The settlement having risen in importance, the company, in 1805, determined to constitute it a regular Government, subordinate only to the Governor-general of India; but, on account of the enormous expence incurred by the establishment, some modifications were made in it in 1808.

The fort, which is called Fort Cornwallis, is built on the north-east point of the island. It was originally badly constructed; and large sums have been spent upon it without completing it. It is incapable of defence, from its size and construction. In the fort are barracks for the military, the arsenal, magazine, and military store-houses. The sea has of late years made encroachments on the north face of the fort, and along the esplanade, and for upwards of a mile in that direction. The town, called George Town by the English, and Panjang Panaique by the Malays, is of considerable extent. It is bounded on the north and east by the sea, on the south by a small river, and on the west by the high road. The streets, which cross each other at right angles, are spacious and airy; but having been at first merely lined out, without being either raised or drained, were frequently impassable after hard rain. This inconvenience has been removed, as the principal streets are now properly raised and drained; and the town has in consequence improved much in appearance and cleanliness. There is a large pier for landing and shipping goods, to which fresh water is conducted by pipes. Since the island has become the seat of government, considerable alterations have taken place in every department. A government house, a church, a jail, and several substantial bridges, have been built; the fortifications have been improved and strengthened, and the public roads repaired and widened. The markets are well supplied with fish of various kinds, and of excellent quality; poultry of all sorts, pork, grain of every description, and a great profusion of fine fruits and vegetables. The beef and veal are not of a good quality; sheep are imported from Bengal and the coast of Coromandel; goat mutton is procured from the Malay peninsula and Sumatra. Milk, bread, and butter, are very dear, and the first very scarce. Almost all the country ships bound to the eastward, particularly those for China, touch here, where they refresh and purchase such articles of trade as they have room for. The East India Company's ships bound to China touch also here, and load large quantities of tin, canes, rattans, sago, pepper, betel-nut, birds' nests, &c. for the China market, as also to serve for dunnage for their teas to Europe.

The imports from Europe, either directly or from the other Presidencies, are generally European manufactures in iron and steel; such as anchors, cutlery of all sorts, fire-arms, nails; also tin-ware, patent shot, sheet lead, sheet copper, iron in bars, boots and shoes, cables, canvas, cabinet-ware, cloths and cassimeres, glass-ware, hats, haberdashery, hosiery, musical and mathematical instruments, oilman's stores, painters' colours, plated-ware, watches, malt liquor, and European wines of all sorts. The value of the goods imported from England amounted in 1807 to L.76,000; in 1810, to L.38,253. Large quantities of Bengal and Madras piece-goods are imported for the Malay trade, and the consumption of the European residents. The other articles imported are opium, grain, tobacco, red wood, sandal wood, shark fins, myrrh, pepper, rice, betel-nut, benzoin, camphire, gold dust, elephants' teeth, &c. A great many of these commodities are re-exported to Sumatra, Ceylon, and the other Indian islands; also to China, to Bengal, and Coromandel. Long. of the north-east point, 100° 19′. E. Lat. 5° 25′ N.—(*From the Edinburgh Gazetteer, or Geographical Dictionary,* Vol. V. Part I.)

Prince of Wales's Island.

PRINTING.

The article Printing, in the *Encyclopædia*, brings down the history of this invaluable art to the year 1790, and describes the presses and other implements in use at that period. In this article it is proposed —1. To give a short detail of the principal improvements which have since taken place; and 2. To give some account of Stereotype printing, a slight notice only of which is contained in the *Encyclopædia*.

Few of the mechanical arts seem to have made such rapid progress to perfection as that of printing. For centuries after the invention little seems to have been attempted in point of improvement, and nothing discovered of material use; indeed, in all the essentials of printing, many of the earlier productions of the press equal any thing that has since been produced. The printing-press, used in the infancy of the art, remained without improvement till about 1620, when William Jansen Bleaw, of Amsterdam, fabricated the press, which, till very lately, was in universal use; and till the beginning of the eighteenth century, and the establishment of the elder Caslon's letter-foundery, the printers of Britain imported nearly all their types from Holland.

William Caslon, to whom English typography is so much indebted, was originally an engraver of ornaments on gun-barrels, and was first employed to make punches for an Arabic New Testament in 1720. Under the patronage of Mr Bowyer, he, in 1722, cut the beautiful English letter which was used in printing Selden's works, 1726; and after improving the art of letter-founding, in all its parts, and carrying on an extensive business for nearly half a century, he died in 1766, leaving a son, by whom the foundery was carried on, and individuals instructed by him, who still further improved the art of letter-founding. The chief of these was Joseph Jackson, who cast a fount of letter for the Domesday Book, and furnished the types for the *Bible* published by Mr Macklin. Mr Jackson died in 1791. (Nichols's *Lit. Anec.* Vol. II. p. 355.)

Another individual, who acquired some celebrity in his attempt to improve English typography, was John Baskerville. Mr Baskerville was born at Wolverley, in the county of Worcester, in 1706. He was trained to no occupation, but in 1726 became a writing-master in Birmingham. He afterwards betook himself to the occupation of a japanner; and in 1750 turned his attention to printing. He manufactured his own paper, types, and ink; and his first attempt was a 4to edition of Virgil, printed in 1756. He obtained leave from the University of Cambridge to print a *Bible* in royal folio, and two editions of the *Book of Common Prayer*, in three sizes, for which permission he paid a premium to the Society. The *Bible* was printed in 1763. He also printed, in royal 4to, editions of Terence, Catullus, Lucretius, Sallust, and Florus. Mr Baskerville died in 1775, and his types, &c. not finding purchasers in England, were sold to a Literary Society in Paris, for L. 3700. (Nichols's *Lit. Anec.* Vol. III. p. 450.)

The exertions of Caslon and of Baskerville to improve the form of the types and render the letter-press more attractive, were not without their effect in introducing a taste for superior printing. Bodoni of Parma, Didot of Paris, and Bensley of London, successively called the public attention to specimens of typography, of an elegance till then unknown; and the grandsons of the first Caslon had the merit of producing specimens of types, which showed that even the form of the letters might be altered with advantage. Messrs Caslon and Catherwood published their specimens of these improved types in 1803: William Caslon junior began his improvements about the same period; and they were speedily followed by Messrs Fry and Steele, and all the other letter-founders in London. These improvements consisted chiefly in the hair-strokes of the letters being made finer, and the main body, or stalk, bolder. Many of the double or tied letters were also at this time discarded, such as the sh, ss, st; and the long s was finally exploded. The form of the letters was also improved, by rounding the terminations of several which formerly ended in acute angles; and the Italic types, in particular, were so much altered, as to present the appearance of beautiful writing.

When the taste for printing in better style began to gain ground, it was soon found that the common press was deficient in the necessary power to produce a sharp and beautiful impression of the types. Besides this want of power, which rendered the operation of printing a very severe one for the workmen, it had another palpable defect in its only printing half the sheet of paper at one pull. Many attempts were of course made by individuals to remedy these defects, and with various success. One of the first of these was an improvement of the common press, which took its rise in France. It was a wooden press of the ordinary construction, except that the platen was formed of an iron plate instead of wood, and made sufficiently large to print the whole side of the sheet of paper at once. The under surface of this plate was covered with brass. The screw or spindle, instead of being turned by the bar or lever in the usual manner, was united by connecting rods with a strong lever placed at the side of the press, and it was worked by the man applying both hands to the lever to bring it down, nearly by the same action as working the lever of a common pump. But although additional power was thus procured, the exertion required from the workmen rendered this press unfit for general use. French Press.

In the year 1796, Thomas Prosser, of London, obtained a patent for an improvement of the printing-press. The chief feature of this invention was an attempt to increase the power by the addition of a spring between the cap and head to resist the Mr Prosser's Press.

pressure upwards, and a similar one under the lower board or winter, to resist the pressure downwards. (*Repertory of Arts*, Vol. VIII. p. 368.)

Mr Roworth's Press.

Another improvement adapted to the common press was made by Mr Roworth, a printer in London, which he is said to have found successful in a long course of practice. Instead of the screw, Mr Roworth substituted a plain vertical spindle, furnished with a bar, hose, &c. as in the common press: but the upper part, where the thread of the screw is usually cut, was a plain cylinder, fitted into a socket in the head of the press. Upon the upper end of the spindle, just beneath the head, a short cross arm is fixed, which acts against a circular inclined plane, fixed under the head of the press. On turning the bar or lever, this short arm, by its action on the inclined plane, causes the spindle to descend in the same manner as the screw; but with this advantage, that the inclined plane is formed so as to give a rapid descent to the spindle when the action first begins; and when the platen comes in contact with the tympan and types, and the pressure is begun, the plane has a very slight inclination, and a power which increases as the resistance increases. The inclined plane and cross arm of Mr Roworth's press are formed of hardened steel.

Mr Brown's Press.

In 1807, Mr John Brown, of London, obtained a patent "for improvements in the construction of a press for printing books and other articles, part of which may be applied to presses now in common use." Mr Brown's press is of iron; the pressure is produced by a screw, which is put in action by a bevel-wheel and pinion. The handle which gives motion to these is fixed on a spindle, or shaft, attached to the side of the press. Another handle which moves the bed with the types, likewise puts in motion two rollers or cylinders, covered with flannel or any other elastic substance, and this again with parchment or vellum, which rollers revolve and feed the types with ink. Mr Brown, from the specification of his patent, seems to consider this mode of inking the types as his chief improvement, and applies his invention to the common press by means of a fly-wheel or treadle, which puts in motion the two rollers or inking cylinders. (*Repertory of Arts*, Second Series, Vol. XIV. p. 368.)

The Stanhope Press.

But the most successful improvement upon the printing-press was about this period made by the late Earl of Stanhope, whose genius for mechanics led him to turn his attention to this important machine. The Stanhope Press, as it is named from the inventor, is formed of iron, and prints the whole surface of the sheet of paper at once. The most important part of his Lordship's invention, however, consists in his having obtained, by a combination of levers, the requisite power for this purpose, without the excessive labour of the common press, where the lever or bar is fixed upon the axis of the screw. It consisted in applying a short lever upon the top of the screw of the press, and connecting it by a link with the extremity of another lever, which was fixed upon the top of a spindle or axis placed parallel to the screw. To the lower end of this spindle the handle or lever for working the press was attached; and the relative position of the levers was such, that when the workman first pulls the handle towards him, the platen is moved or brought down with a considerable velocity; but on arriving at the point where the pressure is required, the levers have changed their position in such a manner as to operate upon the platen with a very slow motion, and a power immensely great. This principle has been employed, with certain modifications, in almost every description of printing press that has been brought forward since the date of Lord Stanhope's invention. (See Plate CXI. figs. 1, 2, 3, and *Description*, for the details).

De Heine's Press.

A Stanhope press of a new construction was afterwards invented by Augustus Frederick de Heine, of London, and a patent procured for it in 1810. The principle of this invention is the application of two sectors, or a sector and a cylinder, or a sector and a roller, to move one against the other by a single or compound lever. Mr de Heine's press is of iron, as the Stanhope press; the only material improvement being the substitution of a spiral or curved inclined plane in place of the screw. In turning the lever, the piston attached to the platen is depressed as by the common screw, but with this difference, that as the descent of the piston increases in velocity, the power increases in the same proportion. In the screw the descent is equal, and the power, of consequence, equal. The lever is fixed to a moveable spindle, and a regulating screw is fixed at the top. A discovery similar in many respects to this had been made, as formerly mentioned, by Mr Roworth, and adapted to the common press; but Mr de Heine had the merit of combining it with the iron frame and levers of Lord Stanhope's machine. (*Repertory of Arts*, Second Series, Vol. XVI. p. 321.)

Mr Kier's Press.

Mr Peter Kier, of Camden Town, also made some improvements upon the construction of the Stanhope press, which have been considered as contributing much to the accurate performance and durability of the machine. A cylindrical hole is bored in the centre of the press, and into this a cylinder is accurately fitted, the platen being fixed on its lower end. To prevent the cylinder from turning round, a flat side is made to the cylinder, and a bar of iron is screwed across the two cheeks, which bears against the flat side of the cylinder. Another improvement is in the spindle to which the handle is fixed. This has a screw cut upon its lower end, which is fitted into a nut, and thus, when it is turned round, the spindle rises and falls a quantity equal to the descent of the main screw in the same period. By this means the connecting lever always draws in a horizontal direction. In the other presses one end remains at the level while the other descends, which occasions the joints to wear irregularly.

Mr Brooke's Press.

Mr Brooke, of London, about the same time applied the compound levers of the Stanhope press to the common press with much success; but as the wooden frame of the old press is not calculated to afford the same resistance as those constructed of iron, the power of these presses is, of course, much inferior. Mr Brooke's improvement, however, has been pretty universally adopted.

Mr Medhurst's Press.

Mr Medhurst, of London, is also the inventor of a printing-press of great merit, from the simplicity of

its construction, and which has nearly the same advantage in point of power as that of Lord Stanhope. It is a common press in all its parts, but the platen is made the full size of the sheet, and instead of a screw a plain spindle is employed. On the lower part of the spindle, just above the bar or lever, a circular plate is fixed, which affords steps for the points of two iron rods which extend up to the head, and are there supported by their points entering sockets. When the platen is up, these rods stand in an inclined position; but when the spindle is turned by the lever, the circular plate in which the lower end of the rods rest turns round likewise, and the upper end remaining stationary, they come into a vertical position, in which motion the spindle and attached platen are forced to descend in the same manner as though a screw were employed. This motion seems to have every advantage of the Stanhope levers or Mr Roworth's press, without the friction of either; for the power increases as the resistance, and when the rods come nearly parallel to the spindle, or in a vertical position, it is immense.

Mr Ruthven's Press.

In 1813, Mr John Ruthven, of Edinburgh, took out a patent for a printing-press, by which the necessary power is produced by a combination of levers alone. This ingenious mechanist, from being himself a printer, had long observed the defects of the common press, and set himself to remedy them; but finding this impracticable to the extent he wished, he at last succeeded in producing the printing-press which now goes by his name. Mr Ruthven's press differs from all those formerly invented, in the platen being moveable and the types stationary. The platen is the size of the sheet to be printed; there is no central pressure, the platen being drawn down by the two ends; and the resistance, being sustained against the under side of the table, affords complete security to all the parts. But the construction and appearance of this press will be best judged of by a reference to the plate. (See Plate CXII. figs. 4, 5, 6, and *Description.*)

Mr Ruthven makes these presses of all sizes, from a cubic foot to the largest newspaper size; and by an ingenious application of the same principle, has formed very useful machines for copying letters, printing from stone, &c.

Columbian Press.

What is called the Columbian press is also formed to operate by a combination of levers, and is probably the most powerful of any of those constructed on this mechanical power. This press, which is now very generally introduced, was invented in 1814 by Mr George Clymer of Philadelphia. Its success in America induced the inventor to come to London in 1818, where he established a manufactory for its fabrication; and the trials it received there in some of the largest printing-offices, soon called the attention of the trade to this ingenious machine. A front and side view of it are given in Plate CXI. figs. 7, 8, from which its movement will be readily understood. The ornaments, which are formed upon the castings of the frame and levers, and which give this press so distinguished an appearance, are, however, omitted in the engraving, on account of the diminished scale of the figures.

Barclay's American Press.

Another press of American invention has been lately imported into this country by Mr David Barclay, who has obtained a patent for it. The power in this machine is produced by a wedge acting upon two cylinders, which again act upon inclined planes. The construction of this press is sufficiently simple, and it is said to work well, and with much ease to the workmen. (See Plate CXII. figs. 1, 2.)

As adapted to the improved presses which are capable of printing double sized sheets of paper, it may be farther mentioned, that Mr Thomas Curson Hansard of London invented dividing tympans, which, in the process of printing, cut such double sized sheets to the ordinary size. This invention was secured to him by patent dated the 1st of November 1817. (*Repertory of Arts*, Vol. XXXIII. Second Series, p. 257.)

These are the chief improvements which have been made in the construction of the printing-press within the last thirty years; and previous to that period little or nothing had been done to improve this useful machine. But not only was ingenuity successfully applied to increase the power, and lessen the labour required in working the common press, but attempts were made, and with more success than had been anticipated, to render manual labour in this department of printing almost unnecessary, by the invention of machinery.

Machine Printing.

Nicholson's Machine.

The late Mr William Nicholson of London was, it is believed, the first who proposed the introduction of a machine for printing, which should supersede entirely the ordinary press. He obtained a patent, dated the 29th April 1790, "for a machine or instrument for printing on paper, linen, cotton, woollen, and other articles, in a more neat, cheap, and accurate manner than is effected by the machines now in use." A description of this machine, illustrated by figures, is inserted in the *Encyclopædia*; but as far as regards book printing, Mr Nicholson's invention was found impracticable, as it required the types to be so formed as to be fixed upon the surface of a cylinder. The ink was supplied by a cylinder or roller covered with soft skin, and stuffed with hair or wool, and the quantity was regulated by smaller cylinders, which acted so as to distribute it equally upon the larger one. This last part of Mr Nicholson's invention, however, or the idea of inking the types in printing by means of a roller, in place of the balls formerly used, has been since improved upon, and is now universally adopted.

Bacon and Donkin's Machine.

Another machine for printing was invented by Messrs Bacon and Donkin, for which they obtained a patent in the year 1813. This machine is so far different from Mr Nicholson's, that in place of the types being required to be cast so as to be arranged on the surface of a cylinder, they are firmly fixed in pages or galleys upon the surface of a revolving prism, having four, five, or any required number of sides. This prism is mounted in a frame so as to be capable of turning round on its axis, and is called the Printing Prism. Beneath this a revolving platen is mounted on an axis, the circumference of the platen being so formed, that it always keeps in con-

Printing.

tact with the surface of the types or blocks upon the printing prism. The types being inked, and the machine put in motion, the paper to be printed passes between the prism and the platen, and thus receives the impression. The ink is applied to the types by means of a roller or cylinder with an elastic surface, which is formed so as to turn round in contact with the printing prism. But the structure of the machine will be best understood from the plate and accompanying *Description*. (See Plate CXIII.)

Shortly after the patent was procured, one of these machines was employed by the University of Cambridge for printing *Bibles* and *Prayer Books;* but its structure, though very ingenious, was too complicated, and too liable to derangement, to give any hopes of its being generally adopted; and the subsequent invention of a machine upon a different principle, and of which the moving power was steam, has rendered prior inventions of comparatively little value.

Bensley's Machine.

This ingenious application of machinery to the operation of printing was the invention of M. König, a native of Saxony, and a printer. M. König is said to have, many years ago, turned his attention to this subject, though his first efforts were bounded to give an accelerated motion to the common press. Failing in his applications to the most eminent of the continental printers, he came to London about 1804, and submitted his scheme to several printers of repute in that city. By most of these his proposals were coldly received; till fortunately he was introduced to Mr Bensley, senior, who, judging favourably of M. König's plans, entered into an arrangement with him for the purpose of carrying them into execution.

Mr G. Woodfall and Mr R. Taylor now joined the projectors; but the former having soon retired from the concern, the remaining gentlemen persevered in their experiments to fabricate a press which should have accelerated motion, and render the work of a man to ink the types unnecessary. After many experiments, however, and considerable expence, it was discovered that the attempt to improve the common press could never be attended with any great results, and attention was now turned to printing by means of a cylinder.

After some years of renewed experiments, a small machine was at last produced, which promised to be successful. The principle of this machine was, that the operation of printing was performed by the sheet of paper passing between a large cylinder, which gave the pressure, and the form of types. In place of balls used by hand, rollers, covered with leather, as in Mr Nicholson's invention, were substituted; under which the form of types passed its way to the printing cylinder. The action of this model now showed the practicability of extending the same principle to a more powerful machine; and on exhibiting it to Mr Walters, proprietor of the *Times* newspaper, and pointing out the further improvements which had suggested themselves, an agreement was entered into with that gentleman for the erection of two large machines for printing his journal. The machines were accordingly erected; and so secret had been the operations of the patentees, that the first intimation of their invention was given to the public in the *Times* of Monday, the 28th of November 1814, the reader of which was told that he then held in his hand a newspaper printed by machinery and by the power of steam.

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The next step in the improvement of the machine was to fabricate one which should print both sides of the sheet at once; the first one erected being merely calculated to do this in succession, or one form of types after the other. A machine on this principle was accordingly erected for Messrs Bensley, complicated indeed, but not more so than might have been expected, from the difficulty of making the pages fall precisely on the back of one another. As the strained skins by which the ink was applied to the types were found unequal in their surface, the inking cylinders were now covered with an elastic preparation of glue and treacle, which has been found to answer completely. The patentees issued a prospectus, dated 18th March 1817, offering three different kinds of these machines at a high scale of prices; and besides the original purchase money, demanding a large annual premium. But the proposals were so extravagant, that they effectually operated to prevent their adoption by the trade.

Various individuals now turned their attention to the improvement and simplification of the machine, but with little success. At last, however, Mr Dryden, a judicious engineer, under the instructions of Messrs Applegath and Cowper, produced a machine similar in its capabilities to the one last mentioned, but much more simple in its construction. In the old machine it required upwards of 100 wheels to effect the purpose, which in this last improvement is performed by a tenth part of the number. Messrs Bensley's original machine, however, answered many useful purposes; and massive and complicated as it was, in comparison of the more recent improvement, they continued using it till the destruction of their establishment by fire in 1819. The fabricators of the present machine, however, had applied the inking apparatus invented by them to this machine, which, from its simplification, removed no less than forty wheels required to effect the same purpose by the old one. Even after the rebuilding of the premises, the machinery, which had been only partially deranged, was repaired, and worked for some time; but it has now given place to two machines erected on the improved plan, which appear indeed so simple in their operations, as apparently to be susceptible of but little further improvement.

The printing machine as now improved, besides being less cumbrous than that of M. König, produces work of better quality. The double or perfecting machine throws off 800 to 1000 sheets, printed on both sides, within the hour, and the single machine delivers 1500 or 1600 printed on one side. (*Literary Gazette*, No. 301.)

Inking Roller.

Inking Roller.

The old method of inking the types by balls, as described in the *Encyclopædia*, has been superseded by the use of elastic rollers, which fulfil the intention more completely, and with less labour to the workmen. The first idea of a roller for this

purpose seems to have occurred to Mr Nicholson; this being a necessary part of the apparatus of the printing machine, for which he obtained a patent in 1790, and it has formed an appendage in every machine since proposed. At the first outset, the rollers were made of leather stuffed in the manner of a cushion; but they were soon found to lose their elasticity and to grow hard, and by the unequal stuffing, to ink the types irregularly. A composition of glue and treacle spread upon canvas, which was used in some printing offices to cover the stuffed balls in place of skins or soft leather, was afterwards applied to a cylinder, and found not less admirably calculated for the operation of a machine, than for printing by manual labour at the ordinary press.

On the introduction of the inking roller, many devices were fallen upon to supply it regularly with ink. Of these it is scarcely necessary to give a detailed description in this place. An inking table formed of a plate of cast iron, with a longitudinal trough or box at one end to contain the ink, seems best adapted to the purpose. A metal roller, in the centre of this trough, and of which a small part of the surface is exposed, turns in the centre of the trough of ink, and a steel bar along its upper surface, fixed by screws, regulates the quantity given out. The elastic roller, on being pushed up to the trough, receives a stripe of ink throughout its whole length, which is distributed equally over its surface, by rolling on the table before being applied to the types.

The roller is cast in a mould, upon a core of hard wood, which is mounted upon a light frame of iron, so as to revolve freely upon pivots, with two handles for the workmen to use it.

Mr Thomas Parkin of London has lately invented an apparatus to facilitate the operation of inking by composition rollers, which is said to be capable of being applied to most printing presses. Of this apparatus there is a sketch in Plate CXI. figs. 4, 5, and 6. But it has not yet been established for a sufficient length of time, to authorize a judgment to be formed of its superiority to the common mode of using the elastic roller.

Stereotype Printing.

Stereotype printing (from ςτερεος, solid or entire, and τύπος a type) is the art of printing from solid plates instead of moveable types. Though printing from wooden blocks has been known for fifteen or sixteen centuries in China; and although this was the first form in which books were printed at the invention of the art in Europe, yet the Chinese blocks, and other similar devices, are in reality only a species of engraving. The letters are cut in the block by the artist, and the impression is produced directly from it; while in the formation of stereotype plates, a mould is first formed from the page of moveable types, and from this mould, a fac-simile of the original page is cast, from which the impressions are taken.

The history of stereotype printing has been hitherto involved in considerable obscurity; and Holland, France, and Scotland, have contested the merit of its discovery. The Dutch claimant was J. Vander Mey, father of the well known painter of that name, who resided at Leyden about the end of the sixteenth century. His pretensions were stated in the *Niew Algemein Konst en Letter Bode*, 1798, No. 232, in which it is asserted that the Dutch had been in possession of the art of printing with solid or fixed plates for above 100 years. With the assistance of Muller, the clergyman of the German congregation at Leyden, who superintended the correction, Vander Mey is said to have prepared and cast the plates for an edition of the *Bible*, which was printed in 4to, and the forms of which were in the possession of G. and J. Luchtmans of Leyden. A folio edition was likewise prepared in the same manner with large margins, ornamented with figures, the forms of which were in the possession of Elwe, a bookseller at Amsterdam. Besides these, an English *New Testament*, Shaaf's *Syriac Dictionary*, 2 vols. 4to, and a small Greek *Testament*, were printed by Vander Mey in this manner; but at his death the art of preparing solid blocks was said to have been lost, or not afterwards employed on account of the expence. (Tilloch's *Philosophical Magazine*. Vol. X. p. 275, 276.)

Such are the pretensions of the Dutch to the honour of the invention of printing by means of stereotype. But unfortunately for this claim, M. Camus, who published two papers on Polytype and Stereotype in the *Memoirs of the National Institute of France* (Vols. III. and V.), in his anxiety to do justice to the merits of a countryman of his own, was led to make some inquiries regarding the existence of Vander Mey's plates of the *Bible*. The result was, that he found these plates were still in existence, and in the possession of Messrs G. and J. Luchtmans of Leyden; the grandchildren of Samuel Luchtmans, the bookseller, at whose expence it appears Vander Mey had originally prepared them. From a letter of these gentlemen to M. Renouard, a bookseller in Paris, dated 21th June 1801, accurately describing the plates of this *Bible*, it turns out that the forms of types have no analogy at all to modern stereotype plates, but are merely the pages of common moveable types, soldered together at the bottom: "c'est une reunion de caractères ordinaires par le pied avec de la matiere fondue." (*Mém. de l'Instit.* Tom. V. p. 330.) The Dutch *Bible* in folio, we learn from the same authority, was at that time in the hands of Elwe the bookseller, and the Greek *New Testament* in the hands of Messrs Luchtmans. The forms of the other works mentioned as having been prepared in this manner had been broken up and sold.

M. Camus having disposed of the pretensions of Vander Mey, his next object was to support the title of one Valleyre, a Paris printer, to the merit of the invention; at least to the practice of printing from stereotype plates. In his first memoir (*Mém. de l'Inst.* Tom. III. p. 440), he claims the invention for the French; 1*st*, Because, in a modern catalogue of the printers of Paris by Lottin, it is asserted, without any proof of the fact being adduced, that the calen-

dars at the beginning of church books were printed from solid plates towards the end of the seventeenth century. *2d*, From the existence of a plate formed of copper, of which he has given an impression in his memoir, containing a page of such a calendar; and *3d*, From the testimony of a compositor, who had been witness of the use of such plates in the office of Valleyre, prior to the year 1735. Two other pages of a similar calendar were in the possession of M. Herhan; but unfortunately, notwithstanding one of these contained the months of January and February, and another the months of November and December, the year to which they referred was not inserted; nor was M. Camus's industry sufficient to procure one of those church books printed by Valleyre to ascertain this fact, though, from their nature, it is reasonable to conclude the impressions must have been numerous.

It is scarcely necessary to make any remarks upon this claim of M. Camus for the invention being French. Lottin's catalogue is of no authority on the point; and the recollection of a nameless compositor, who must have been nearly eighty years of age, concerning a circumstance which happened sixty years before, is not more satisfactory. It seems, therefore, more than probable, that the plates of the calendar alluded to, which, if complete, would have only amounted to six very small 24mo pages, had been formed by some Parisian printer, who had heard of the invention of Ged, and attempted to imitate it; or, if they can be really proved to have been manufactured previous to 1735, the material, and the manner of their formation, were so different from his, and so nearly similar to the head and tail pieces fabricated by the Dutch founders for centuries before, that all claims to the invention of stereotype, as now practised, by Valleyre or his predecessors, must fall to the ground.

It may be mentioned that these plates of copper containing the calendar seem to have been cast, and that not very perfectly, from a mould formed of sand, clay, or some similar substance; precisely in the same manner that, till within these twenty years, the larger letters and vignettes used in printing were fabricated by the ordinary letter-founders, both on the Continent and in England. We have seen many of these antique decorations cast in type metal of the thickness of stereotype plate, and fastened to blocks of wood to raise them to the proper height; and though the transition from this to stereotype plates appears sufficiently obvious, yet it seems quite certain, that till our ingenious countryman, William Ged, attempted and perfected the process, in a manner that had not before been practised, the art of stereotype printing was unknown.

William Ged, the inventor of printing from plates in place of moveable types, and whose invention has formed the basis of all the subsequent attempts in the art, was a goldsmith in Edinburgh, in which profession he is said to have made many improvements, which he liberally communicated to the other members of the trade. In the year 1725, happening to be in company with a printer, the conversation turned on the disadvantages which persons in that profession experienced from want of a letter-foundery; the printers at this time, both in Scotland and England, being chiefly supplied with types from Holland. Mr Ged's friend then showed him the types, both singly and put together in pages, and asked him if he could contrive a method to remedy that defect. "I answered" (says Mr Ged, in a narrative dictated by himself a short time before his death), "That I judged it more practicable for me to make plates from the composed pages than single types. To which he replied, that if such a thing could be done, an estate might be made by it. I desired he would give me a page for an experiment, which, after some days trial, I found practicable, and so continued for near two years improving on my invention, and making a great many experiments, several of which were expensive; but the more I practised, and the less chargeable materials I used, I was the more successful, till at last I brought it to bear, as that no distinction could be made between the impression from my plates, and that from the types." *

Mr Ged's invention was now complete; and nothing but the want of capital hindered its being brought before the public in the most complete manner. To procure the necessary funds, he, therefore, in 1727, entered into a contract with a gentleman of Edinburgh, who, for a fourth share of the profits, agreed to advance the money that might be necessary for carrying on the work. But the jealousy of trade soon interrupted Mr Ged's progress; for his partner, consulting with a printer on the subject, was led to believe that his whole fortune would not be sufficient to complete the undertaking. This representation so intimidated the monied man, that in two years he had made no farther advance than L. 22; and so, says Mr Ged, "finding no appearance of success that way, I was glad of an opportunity by which I might expect better encouragement."

In July 1729, Mr Fenner, a London stationer, being in Edinburgh, and hearing of Mr Ged's project, made him proposals for carrying it on in London. He was, accordingly, induced to enter into a contract with that gentleman; obliging himself to share with him the profits of the proposed concern, on condition that he advanced the money that should be required. Mr Ged, accordingly, removed to London; but not finding that his partner Mr Fenner had provided the necessary accommodation and funds, Thomas James, a letter-founder, and his brother John James, an architect, were successively adopted into the copartnership; and some time afterwards, a privilege was obtained from the University of Cambridge, in the name of Fenner, for printing Bibles and Prayer Books on the new plan. This connection turned out unfortunately for Mr Ged;

* See *Biographical Memoirs of William Ged; including a particular Account of his Progress in the Art of Block-Printing.* Nichols, London, 1781, p. 1.

for Thomas James, whose types were little calculated to do honour to their exertions, had, it is alleged, leagued with the King's Printers to defeat a measure which might eventually hurt their interests; and it seems to have been the object of Fenner, after acquiring sufficient knowledge of the art to carry it on without assistance, to drive Ged from the concern.

To accomplish their purposes, these persons are said to have engaged only such people, and procured only such types as were most likely to render the undertaking abortive; and the workmen themselves, averse to an invention which promised to lessen the demand for their labour, were not backward in lending their assistance to the same end. One of the workmen engaged in the business informed Mr Mores, that the compositors, when they corrected one fault, purposely made half a dozen more, and that the pressmen, when the masters were absent, broke the pages intentionally in aid of the compositors. The consequence was, that the Bible and Prayer Books printed in this manner were suppressed at the University; the plates were afterwards sent to the King's Printing-house, and from thence found their way to Mr Caslon's foundery. (*Memoirs of Ged*, p. 36.)

Disappointed in his prospects, and depressed by the ill-usage which he had experienced from all with whom he was connected in this unfortunate speculation, Mr Ged returned to Edinburgh. His friends in this city being anxious that a specimen of his art should be published, a subscription was opened for this purpose, and an edition of Sallust was finished in 1739, in 150 pages 12mo. We copy the title-page of this curious and interesting monument of Ged's ingenuity: "C. Crispi Sallustii Belli Catilinarii et Jugurthini Historiæ. Edinburgi, Gulielmus Ged, Aurifaber Edinensis, non Typis mobilibus, ut vulgo fieri solet, sed Tabellis seu Laminis fusis excudebat, MDCCXXXIX."

Even in getting this small work carried through the press Mr Ged met with difficulties, which it is painful to believe should have obstructed his progress. No compositor could be found to set up the types from which the plates were to be fabricated; and the whole of the work was composed by his son James, then a boy about twelve years of age. He had been put apprentice to a printer about a year before, and with the consent of his master, he was allowed to work at this task in the night time when all the workmen were absent.

What became of the plates of this volume is not well known. Mr Alexander Tilloch, the ingenious editor of the *Philosophical Magazine*, and the second inventor of the art of stereotype printing, relates, in a paper on the subject in the tenth volume of that work, that he was in possession of one of them. "This plate," says he, "I first saw in the hands of the deceased Mr John Murray, bookseller, in the year 1782, but do not now recollect the way in which he said it came into his possession. Having, about a year ago, applied to his successors in business, Messrs Murray and Highley, to request, if the plate could be found, that I might be allowed to take some impressions of it, they very politely insisted on my acceptance of what they had used for years as a flat weight to lay upon papers at the end of the desk." (*Philosophical Magazine*, Vol. X. p. 273.) Philip Denis Pierres, an ingenious printer of Versailles, had, along with a copy of the book, the plate of page 44, so early as 1773. Its size, appearance, &c. is minutely described in the first memoir of M. Camus (*Mém. de l'Inst.* Tom. III. p. 445); and Pierres, we are given to understand, made many fruitless attempts to discover the mode by which it was produced.

Some years afterwards another work, which is less known, was undertaken and finished by Mr Ged. This was *The Life of God in the Soul of Man*, in a small writing pot 12mo. The imprint of this little volume, which is as well executed as books were generally at the time, is, "Newcastle: Printed and sold by John White, from plates made by William Ged, goldsmith in Edinburgh, 1742." Mr Tilloch was in possession of a copy of this volume; and in the *Philosophical Magazine* has given an impression of a page of Ged's Sallust, and specimens of his own and Mr Foulis's stereotype, in Greek and Roman letters. (Vol. X. p. 272.)

William Ged died at Edinburgh, in but indifferent circumstances, on the 19th of October 1749, after having invented, and dedicated the greater part of his life to the improvement of an art from which neither he nor his family were destined to receive any benefit. From the testimony of his daughter, however, it appears that advantageous terms had been repeatedly offered to him if he would remove to Holland, or sell his invention to the printers of that country; but that he uniformly rejected offers, the acceptance of which would have had the effect of giving an advantage to strangers over the artists of his own country. (*Memoirs of W. Ged*, p. 26.) His son, James Ged, whom the disappointments of the family had induced to join the rebel army in 1745, was seized at Carlisle and condemned; but through the interest of some of his father's friends, was pardoned and liberated in 1748. Notwithstanding the ill success his father had met with, he published proposals for reviving stereotype printing, dated at London, 29th May 1751; but these proposals having met with but little encouragement, he went to Jamaica, where he died in 1767. His younger brother, William Ged, had previously removed to the same island, where he died the year after his departure from England; and the name of Ged and the art of stereotype itself was soon forgotten.

Fifty years after the invention of stereotype by Mr Ged, Mr Tilloch was led to a similar discovery, without having, at the time, any knowledge whatever that another had preceded him in the invention. "The knowledge of this fact," says Mr Tilloch, "lessened the value of the discovery so much in my estimation, that I felt but little anxiety to be known as a second inventor; and, but for the persevering attempts of others to deprive Ged of the fame his memory so justly merits, and which he dearly earned, I might still have remained silent." (*Philosophical Magazine*, Vol. X. p. 268.)

Mr Tilloch having communicated his ideas upon the subject to Mr Foulis, printer to the University of

Glasgow, where he then resided, that gentleman furnished him with a page of types ready set up for his first experiment. The success of this trial induced Mr Tilloch to make others; and after numberless experiments, in which he was assisted by Mr Foulis, he was at length able to produce plates, the impressions of which could not be distinguished from those taken from the types from which they were cast.

Mr Tilloch and Mr Foulis, who, as a practical printer, saw all the advantages which the art promised, now agreed to prosecute the business together, and, if possible, to bring it to perfection. In the mean time they accidentally learnt, that the art had been practised many years before by Mr Ged; and a biographical memoir of that ingenious man having been published soon after (in 1781) by Mr Nichols, they discovered that perseverance in the plan might be attended with difficulties which, till then, they had never contemplated. Notwithstanding, however, of the opposition which they were thus led to expect from prejudice and ignorance, Mr Tilloch and Mr Foulis persevered in their object, and took out patents for England and Scotland, dated 14th May 1784, to secure to themselves, for the usual term, the benefits of an invention which they considered as much their own as if nothing similar had been practised before.

Neither the ingenuity of Mr Tilloch, nor the public spirit of Mr Foulis, were, however, rewarded; for, owing to circumstances of a private nature, and after printing a few volumes in this way, the business was laid aside for a time; and Mr Tilloch's removal to London, and other avocations, prevented its being again resumed. The prejudices of the booksellers, besides, were so strong against books printed in this manner, that what volumes Messrs Tilloch and Foulis had completed were sold to the trade without any intimation of their being printed out of the common way. Their first attempts were confined to trifling popular books, such as *The Seven Champions of Christendom*, *The Twelve Cæsars*, &c. and a cheap edition of *The Economy of Human Life*. A Greek volume, however, Xenophon's *Anabasis*, was printed in 1783; and they had prepared plates for several small volumes of the English poets, which, however, were never put to press. (*Philosophical Magazine*, Vol. X. p. 275.)

The art of stereotype printing was thus twice invented and practised in Britain, by natives of Scotland, prior to any thing of the same kind being attempted, or brought to the same perfection, in any other country of Europe.

In the year 1784 Francis Ignatius-Joseph Hoffmann, a native of Alsace, established himself in France as the printer of a stereotype journal, and an improver of the art; but, from the testimony of M. Camus, it would appear that he was in the knowledge of what Ged had previously done, and perhaps also knew of the patent and productions of Messrs Tilloch and Foulis. Hoffmann's process is thus described by himself: "A page set up with moveable types in the usual manner, serves to make an impression in a soft fat earth mixed with plaster, and prepared with a gelatinous paste, formed of gum and potatoe-sediment. This impression became a matrix, in which a composition of lead, pewter, and bismuth, when pressed in at the moment of cooling, gave a solid page, which bore in relief the characters that had served to form the matrix."

By this process Hoffmann printed many leaves of his *Polytype Journal;* and the work entitled *Les Recherches Historiques sur les Maures* by De Chénier, in 3 vols. 8vo, which appeared in 1787. Hoffmann and his son had also procured, in 1785, an extensive privilege for their new mode of printing, and some improvements which they had made in the art of engraving; but by a new order of council, in November 1787, the establishment was suppressed. (*Mém. de l'Inst.* Tom. III. p. 460.)

Hoffmann, thus deprived of his printing office (seemingly from having lent his art to the fabrication of prohibited books), turned his ingenuity to devise some method which should facilitate the ordinary mode of printing. He began with forming two kinds of punches to stamp the characters in his matrices; the first of single letters in the ordinary mode, and the second of the same letters combined into syllables of most frequent occurrence in the French language; such as *ais, etre, eurs, ment*, &c. Hoffmann denominated this invention the *Logotype* art. By this combination the case for the types consisted of no less than 370 boxes. He published a *Memoir* on the subject in 1792; and in the same year procured a patent for his invention for the period of 15 years. Hoffmann does not seem to have been aware that logotype had been proposed by Henry Johnson in 1778; and in France the same plan is said to have been invented by a lady in 1774. (See the Article Logography in the *Encyclopædia.*)

The proceedings of Hoffmann attracted considerable notice in France; and some numbers of his *Polytype Journal* having fallen into the hands of Joseph Carez, a printer at Toul, he was struck with the advantages which it presented, and in 1785 began his operations. His first idea was, to take off the impression of the moveable types in plaster; but he afterwards adopted the plan of impressing the page in metal while at a certain heat; and this impression served him as a mould for casting with accuracy the fac-simile of the original page. In 1786 Carez executed by this process an edition of a church book in two large vols. 8vo, of more than a thousand pages each, twenty volumes of other descriptions, and afterwards a *Bible* in nonpareil characters, the execution of which is indeed very creditable to his ingenuity. (*Mém. de l'Inst.* Tom. III. p. 467.)

Other individuals, whom the attempts of Hoffmann excited to experiment, also made new discoveries in the art, or improved those already known; and all the departments of printing were afterwards improved by the artists called in to assist in the manufacture of *Assignats* at the period of the French Revolution, who were prompted to exertion, as M. Camus expresses it, "by a power which nothing could resist." Among the artists who assisted in the fabrication of Assignats, Firmin and Henry Didot, Louis Etienne Herhan, and Nicolas Marie Gatteaux, severally obtained patents for different modifications of stereotype printing in the year 1798.

From the specification in the patent of Herhan,

his mode of stereotyping seems to have been particularly ingenious. He invented moveable types, in which the letters, in place of being in relief, were sunk (*en creux*); and by merely setting up these types, or rather matrices, which were of copper, he was enabled to produce from them directly a stereotype plate, without the necessity of an intermediate moulding. Herhan printed specimens of this mode of stereotyping by moveable matrices of copper, which are extremely pretty. One is inserted in the *Memoirs of the Institute*, Vol. III. 510.

M. Poterat, many years afterwards, with a view to avoid the difficulty and expence of composing with matrices, suggested a plan by which the matrix of copper is soldered to the bottom of the types, which bear the characters in relief. But this plan is attended with an expence which more than counterbalances the proposed advantages.

Soon after their patents were obtained, Pierre Didot, the elder, Firmin Didot, his brother, and Louis Etienne Herhan, issued a prospectus for printing works in stereotype. An edition of Virgil in 18mo was published in the year 1798; and in spite of the clamours of those interested in opposing the scheme, Phædrus, and successively afterwards many splendid works, were given to the world, by which these individuals have rendered their names celebrated as improvers of the art of printing. (*Mém. de l'Inst.* Tom. III. p. 502.)

M. Camus thus describes the mode of stereotyping practised by Didot and Herhan; only concealing the composition of the metal of which the types used in stereotyping were formed, and that of the metal which formed the mould.

The types are cast in the ordinary mode, but of metal of a particular composition, and sufficiently hard to bear without injury the pressure required to stamp the metal matrix. After the page is composed, it is enclosed in a steel box, where it is compressed on all sides, and the surface made accurately plane. The page thus disposed serves for a punch. The metal plate intended for the matrix has two essential qualities, that of being able to receive a pure and distinct impression, and that of not being subject to any alteration, or commencing fusion, when by the action of a press it is brought into contact with the heated metal. The punch, or page of moveable types, is now placed above the matrix, and an equal pressure is made upon it by a machine, in some respects resembling that used in giving the impress to coin. The matrix is afterwards fixed in a frame, and is ready for the next operation, which the French founders consider as one of the most essential in the process. A table firmly fixed to the ground is provided, and at one side of this table two pieces of wood of convenient height are fixed, with a vertical groove or canal. A piece of wood furnished with a tongue, or feather, is formed to run in these grooves, so disposed as to act in the manner of the rammer used in sinking piles. At the lower part of this piece of wood, perpendicular to its axis, is fixed a screw, and the box or frame which contains the matrix has in its back a female screw to correspond. The matrix is thus screwed firmly to the mass of wood, or rammer, with its face downwards. A drawer or tray of thick paper, or card, is now placed on the table below the descending matrix. This tray is filled with melted type metal, and when the metal is at the point of congelation, a peg disengages the rammer, which falls with its weight upon the metal, which congeals at the same moment. The matrix is now disengaged from the stereotype page by the blade of a knife, and the operation is completed if all the parts of the process have been well executed.* The rammer is raised by a handle; and a thin slip of copper or brass round the matrix regulates the thickness of the plate. (*Mém. de l'Inst.* Tom. III. p. 492, 493, and 505, 506.)

Previous to this period, it may be mentioned, that Firmin Didot in 1796 prepared an edition of the *Logarithmic Tables* of Callet, much in the manner of Vander Mey's *Bible*. The displacement of a figure in works of this kind, from causes well known to printers, often occasions a serious error; and, with a view to prevent similar accidents, after the pages were composed in the usual manner, and finally corrected, the form of types was soldered at the bottom, by which all chance of a figure being displaced was completely prevented. (*Mém. de l'Inst.* Tom. III. p. 509.)

Towards the end of the year 1798, M. Bouvier, also one of the artists who were engaged in the fabrication of Assignats, stereotyped with considerable success, by a process different from that of Didot and Herhan. The metal of his plate was copper, and his mould was formed of argillaceous earth. M. Camus has given a specimen of a page cast in this way, which, however, does not seem so perfect as those fabricated by the other process. M. Bouvier, in extending his invention, applied it to many other purposes, one of which was adapting it to the printing of music. (*Mém. de l'Inst.* Tom. III. p. 509.)

The success of the French printers in stereotype printing naturally excited the attention of their brethren in England; and the next attempt to introduce the art into England was happily more successful than those which had been previously made. About the year 1800 Mr Wilson, a respectable printer in London, engaged with the late Earl of Stanhope, whose love for the mechanical arts is well known, for the purpose of bringing this mode of printing into general practice. His Lordship is said to have received his first instructions in the formation of stereotype plates from Mr Tilloch, the second inventor, and had afterwards the personal attendance of Mr Foulis for many months at his seat at Chevening, where his Lordship was initiated in the practical part of the operation.

After nearly two years spent in maturing the different processes connected with the operation, Mr Wilson announced to his friends that the ingenuity and perseverance of Earl Stanhope had overcome

* This operation is termed *clichage*, from *clicher*, a word signifying to make fall perpendicularly, quickly, and with force, a matrix upon a metal in fusion.

every difficulty,—that the various processes had been so contrived as to combine the most beautiful simplicity with the most desirable economy,—and that the public might look forward to the period when, by the application of this art to the manufacture of books, the prices of all standard works would be reduced at least thirty, and in many cases forty *per cent*.

In the year 1804 Mr Wilson offered, upon certain terms, the art of printing in stereotype to the University of Cambridge, for their adoption in the printing of *Bibles, Testaments*, and *Prayer Books;* but some differences between the syndics and the printer occasioned the contract to be dissolved. The plan, however, has been since adopted both at this university and that of Oxford; and thousands of *Bibles*, &c. are annually issued from their presses printed in stereotype. The art has also been gradually diffused, not only in the capital, but in other cities of the kingdom; and it was carried on to some extent in Edinburgh by the late Mr Charles Stewart, printer to the University, in the printing of school-books, for which, as insuring greater accuracy than the common mode, it is admirably adapted.

The mode of casting stereotype is sufficiently simple. A page of any work proposed to be stereotyped is set up in the usual manner, with the ordinary moveable types. From this page, when corrected, a mould in plaster, the basis of which is gypsum, is taken off, and from this mould an impression is cast in the ordinary type metal, from which the printing is made. Of course, the whole of a work to be stereotyped is set up by the compositor in distinct pages, from which casts are formed; and from these casts plates are procured from which impressions may be made, exactly the same in every particular as that from the moveable types originally set up. A stereotype plate is, therefore, nothing more than a fac-simile of the page from which it was taken; but the advantage in point of expence is, that a plate of stereotype does not require to be more than the seventh or eighth part of the thickness or height of the ordinary types.

In the selection of a proper substance for the moulds, and the management of the casting, the success of the operation chiefly consists. The head and tail pieces of the older printers were chiefly cast in moulds formed of clay or sand; Ged, Tilloch, and after them Hoffmann, used a composition, of which plaster of Paris was the chief ingredient; while Herhan, Didot, Carez, and others, procured their mould by impressing the types in a soft metal, or metal in the act of congelation. The substance required for this purpose must be of a nature so delicate when soft, as to be capable of receiving an impression from the finest lines, and when dry, must be capable of bearing without injury the action of the melted metal. Gypsum or plaster of Paris, when finely pulverized, and mixed with water, soon becomes hard, and will also bear any degree of heat. But gypsum contracts when exposed to heat, and is liable to warp; it is also difficult to expel the air and moisture which it absorbs and retains. The defects of the plaster of Paris are, therefore, to be counteracted by compounding it with other substances less absorbent; but whatever be added, must be capable of receiving and retaining a fine surface, so as to preserve a perfect polish in the plate to be cast from it. The following simple expedient has been recommended as fully answering this purpose. A quantity of common whiting is dissolved in a tub of clean water, and made nearly of the consistence of what is generally used in white-washing. The plaster is mixed with this solution, which makes it contract but little from the heat, and renders it less liable to crack than when the plaster is employed alone.

In making the mould for the page to be cast, a frame of cast-iron is prepared, nearly half an inch wider and larger than the page or pages proposed to be cast, and nearly an inch deep. This frame determines the thickness and strength of the mould. Four cubic pieces of metal are now required, the height of which should be exactly four-fifths of the height of the types; as on the height of these the thickness of the stereotype plate depends. The page or pages, wedged up as usual in the chases or iron frames commonly used, are now to be laid upon the moulding table, and in the openings at the corners of the page are placed the four pieces of metal, on which the iron frame rests when laid over the page.

To prevent the adhesion of the plaster to the types it is necessary to oil over the surface of the page with a soft brush. Then a quantity of the whitewash is taken into a wooden bowl, and as much finely powdered gypsum added to it as will make it into a thin plaster. When reduced to an equal consistence, it is applied to the face of the types with a painter's brush, so as to fill every cavity; and the remainder is then poured in so as to fill the frame. When beginning to harden, the superfluous plaster is struck off with a straight metal rule, to smooth the back of the mould; and when sufficiently consolidated the mould is separated from the page, and dried in an oven.

The mould properly formed, the next process is the casting of the plate. For this purpose, the dried mould is put in a pan about two inches deep with the face upwards, and a small moveable screw is placed at each side or end of the pan, to fix the frame which contains the mould. The fluid metal (which is of the same composition as that used for ordinary types) is now applied to the mould in the pan, and carried to the oven, in which it should remain from one to two hours, to acquire an equal degree of heat; for, on the principle of equal temperature between the metal and moulds, the success of the operation materially depends; and unless the oven be kept sufficiently warm to raise the temperature of the mould to that of the fluid metal, the experiment cannot succeed.

After the plate has been cast, little imperfections are frequently discovered; such as that of the top of the e or similar letters, having been full of dust when the mould was taken. The workman now takes the plate, and after clearing it of all superfluous metal, pulls a proof, marks the defects, and proceeds to make the requisite alterations. If any letter or word chance to be damaged in the course of the operation, it is cut out, and a letter or word from moveable types of the same size, cut to the proper depth, is inserted in its place. When this is done, the plate is ready for the press. The pages are ar-

ranged upon wooden blocks, and fastened down with slips of brass and a screw.

Such is the process of stereotyping, as usually practised; and such is its accuracy, that plates may be cast from copperplates as perfect as the engraving itself. Wood-cuts and ornaments of every kind may be cast in the same manner.

A patent for producing stereotype plates, in a manner different from that now described, was granted to Mr Augustus Applegath, of Surrey, printer, in April 1818. Mr Applegath's plan, however, is so similar to the process of Didot and Herhan, that it is not necessary to describe it. Both his mould and plates are procured by an impress on the semifluid metal in the act of congelation, in the manner originally practised by the French printers; and the instrument he has invented for stamping the impression is the same in principle, though a little different in form, as the *cliche* or stamping-machine of our continental neighbours. (*Repertory of Arts*, Vol. XXXVI. Second Series, p. 69.)

As connected with stereotype printing, it may be mentioned that Mr T. C. Hansard of London procured a patent, dated the 1st November 1817, for a species of stereotype plate risers, with holdfasts or claws, which are formed of metal, are moveable, and easily adapted to any size of plates or forms. These plate risers were intended to supersede the wooden blocks upon which the plates were generally fixed. (*Repertory of Arts*, Vol. XXXIII. Second Series, p. 262.)

The advantages of stereotype printing are, saving in point of expence, and security against typographical errors. For works in great and general demand, such as the Greek and Roman classics, standard books in foreign languages, Bibles, Prayer Books, School-Books, &c. the saving in stereotyping is considerable. The expence of renewed composition in successive editions is thereby saved; and the additional capital expended in preparing the plates is, perhaps, more than compensated by the facility with which small editions of works can be printed without laying aside a stock of paper in warehouses to meet the gradual sale. But it is only in works of this description that stereotype can be profitably employed. For works of living authors, successively improved by corrections and additions, stereotype printing is quite unsuitable. Mr Wilson, the coadjutor of Lord Stanhope, in extending the practice of the art in England, stated, that the probable saving by stereotype to the public might be from 25 to 40 *per cent.*; but whatever may be the advantages in point of expence, its merit in point of accuracy is unquestionable. Dictionaries, classics, works on arithmetic and mathematics, once made accurate, may for ever be kept so with but little chance of error. (Q. Q. Q.)

DESCRIPTION OF THE PLATES.*

Fig. 1, Plate CXI. represents a side elevation of the improved *Stanhope Press*; fig. 2, a front view, and fig. 3, an horizontal plan; the same letters of reference being used upon all the figures. A A shows a strong cast-iron frame of the form represented in fig. 2: This frame is screwed down upon a piece of timber B, which has another timber C morticed into it at right angles, forming a T frame, to serve as a base for the whole press. D D represent two horizontal rails, having channels formed along their upper surfaces, into which the two rails or ribs upon the underside of the carriage or table E E are adapted to slide. The carriage is put in motion by the action of the handle F and barrel W, which has three strong straps or belts passing round its circumference, as seen in fig. 2; the ends of the said belts being attached to the opposite ends of the carriage, in the manner of ordinary printing presses. The table E E is made perfectly flat upon its upper surface in order to receive the form of the types: *m* represents the tympan, which is jointed to the end of the table; it is composed of a light frame of wrought iron, and fitted up in the usual manner.

The rails D D upon which the carriage runs, are secured to the main frame A A by screw bolts *a a*; the outer extremities of the rails D are united together by cross bars, and supported by an arched frame *b* and upright pillar G, the foot of which is bolted down to the timber C. H H represent the platen, which is guided in its perpendicular motion by a slider, I, moving between angular ribs formed within the opening of the main frame, as seen in fig. 2. The upper part *d* of the frame is considerably enlarged, and is perforated in the centre to receive a brass nut or female screw, through which the main screw of the press works. M shows an upright spindle, the lower end of which is formed with a pivot adapted to turn in a hole at the top of the arch of the main frame; the upper part of the spindle M works through a collar *c*, formed in a piece of metal, which projects from the main frame, and is secured by a screw, as seen in figs. 2 and 3. N represents the handle of the press: it is firmly attached to the lower parts of the spindle M, by passing through a cross hole in the said spindle, and having a nut on the opposite side to keep it in its place. Thus, when the handle is moved backwards or forwards it turns the spindle M round, and by the operation of the lever O, and connecting link P, the motion is communicated to the main screw, by the intervention of the arm or lever R fixed upon the top thereof. The platen is raised up and kept in contact with the end of the screw, by the operation of the balance weight S. The levers N O, and R, fig. 3, are represented in the positions they assume when at rest; but the dotted lines will serve to explain their positions when the power has been applied to the handle N; the motion in that case being limited by the broad part of the connecting link P coming to bear against a projecting rib formed upon the upper surface of the lever O; at which period the lever O and connecting

* Owing to an oversight, some of the figures in Plates CXI. and CXII. have been reversed.

link P will be nearly in one right line, and consequently exerting a very great power upon the lever R; which being nearly at right angles to the connecting link, is in a position to receive the greatest effect from the power applied to the handle N. The degree of pressure may be increased or diminished by the operation of the screw p at the end of the connecting link being disposed so as to admit of varying the effective length of the link.

Mr Parkin's Inking Apparatus.

Plate CXI. fig. 4, shows a side view of the apparatus, which was obliged to be placed vertically in the Plate for want of room. Fig. 5 shows an horizontal plan. A represents a square frame of metal which is mounted so as to slide freely backwards and forwards, being guided between a number of small rollers, b, the pivots of which turn in small standards attached to a fixed frame of cast iron, B, by screws and nuts so as to admit of raising or lowering any one of the rollers in order to adjust the position of the moving frame. I shows the inking roller, which is made of elastic composition, being supported upon pivots working in short pieces of metal which project from the cross bar a of the moving frame. The roller I receives its requisite supply of ink by passing over and rolling across the narrow table or metal plate T, as the moving frame is pushed in or drawn out by its handle H. The ink is distributed along the surface of the table T by means of a small furnishing roller F, being mounted in a carriage so as to be capable of rolling along the surface of the table T in a direction at right angles to the motion of the sliding frame A. The furnishing roller F is made of the elastic composition, and receives the ink upon its circumference, by coming into contact with the ink boxes or reservoirs 1 and 2, situated at each end of the table T. The boxes 1 and 2 contain a supply of ink which finds its way slowly through a fine wire grating forming the face of the boxes; and is taken off upon the circumference of the furnishing roller every time that the moving frame is drawn out or put in. The carriage of the furnishing roller moves upon small wheels along the surface of the lower rail C of the fixed frame, and the pivots of the furnishing roller are not inserted into round holes through the plates of its carriage, but have the liberty of sliding up and down a short distance in oblong holes; so that the circumference of the roller may always accommodate itself to the surface of the table T, along which it moves; the roller being kept down sufficiently by its own weight, in addition to the weight of several small metal rollers which are situated over the roller F, and adapted to bear upon it, for the purpose of distributing the ink more effectually upon its surface as it turns round. The traversing motion of the roller F, and its carriage along the table T, is effected in the following manner. The ends of the carriage have small catgut lines attached to them, which pass over pulleys i i, situated at the ends of the cross rail C; the catgut lines then return under the rail C and pass round small horizontal pulleys k k, fixed also to the lower rail, as shown in fig. 6, from whence they proceed to two pulleys m, one only of which is seen in the drawing fig. 4, being placed close together in one frame, but so as to turn round quite independent of each other. The frame of the pulleys m is screwed to the fixed frame B, and the catgut lines pass up and over two pulleys n fixed in a frame in the same manner as the pulleys m. Both of the pulleys n are seen in the plan, fig. 5, where one of the catgut lines marked o is represented as attached directly to the cross bar e of the moving frame A; and the other catgut line p is conducted over a pulley q, which is mounted in a frame projecting from the fixed cross bar t of the frame B: the line p then returns and is attached to the cross bar e in the same manner as the line o. This apparatus is intended to be fixed behind the printing press (as represented by the dotted lines in fig. 7, Plate CXI.), in such position that the surface of the table T may be exactly on a level with the surface of the form of types to be inked; and so that the pressman may take hold of the handle H, and thereby move the frame A with its inking roller I across the types, to apply the ink and prepare them for printing.

Columbian Press.

A front view of this press is represented in fig. 7, Plate CXI., and a side elevation in fig. 8. A A shows the standards or main frame, of cast iron; they are united together at the bottom, but separate at the top; the main frame is supported upon four legs, x x. B B represent the rails or guides, upon which the carriage or table, C C, with its appendages of tympan, z, and frisket, y, is adapted to run, being moved backwards and forwards by the handle, E, and barrel, F, round which strong linen belts are passed, and affixed to braces v, w, at each end of the carriage, as in ordinary printing presses. D shows the platen, which is guided in its motion up and down by its square stem or pillar, d, being placed angleways, and sliding between pieces of metal, a a, which project from the main frame, A A. The pieces a a are furnished with adjusting screws and wedges for the purpose of tightening them up, and preventing any looseness in the platen. The stem d has a square plate, e, upon it at the part where it joins to the platen. The pressure is produced by a combination of levers situated at the upper part of the frame. G, H, I, shows the main lever, moving on a strong centre bolt at H, between a forked or divided part of the main frame; the end, I, of this lever also passes through an oblong opening formed between the bars, h, and projects some distance beyond the outside of the frame. The central part, G, of the main lever has a strong pivot or trunnion cast upon it, which projects out sufficiently on each side to enter into collars formed at the top of the stem, d, of the platen, being retained in their places by four screw bolts, two of which are seen at G in figure 7. m, n, o, shows the second lever, moving on a fixed centre pin in the main frame at m; it has the links n I jointed to it at the point n, one upon each side, as seen in figure 8: the uppermost ends of these links are also jointed on each side of the main lever at I. The point o of the second lever has the link or connecting-rod, p, jointed to it, whilst the opposite extremity of the connecting-rod is jointed to the lever or handle N, by which the pressman puts the system of levers into action.

The handle N turns upon a fixed centre pin passing through projecting pieces of the main frame, as seen at i i; and the connecting-rod p is furnished with a double or universal joint, where it unites with the lever o, to admit of the oblique motion of the handle N, when it is pulled forwards to produce the pressure.

A counter-lever, r, s, t, is applied at the top of the press, moving upon a fulcrum at s; this lever has a balance weight clamped upon it by a screw at r, whilst the short end, t, of the lever is attached by a link to the end of the main lever at the end I. By this means the weight of the levers and platen is counterbalanced sufficiently to raise them up, when the handle N is left at liberty. The different levers in this press are so arranged, that the first motion which is communicated to the handle N brings the platen down quickly; but by the time that its under surface arrives upon the tympan, the second lever, m, n, is brought nearly in a line with the direction of the links n I, which causes them to draw down the end, I, of the main lever with great power; at the same time that the point, o, of the second lever is in the most favourable position to be operated upon powerfully by the connecting-rod proceeding from the handle N. When the impression is produced, two balance weights act in concert to return the handle N, and raise up the platen. The main frame A A of the press is strengthened by a cross bar situated behind the main lever, which bar serves to connect the top parts of the frame together, as shown by the dotted lines in fig. 7.

Barclay's American Press.

Fig. 1, Plate CXII. represents a side elevation of this press; fig. 2 is a back view; and fig. 3 a horizontal plan, representing the table or carriage as partly run in. The same letters of reference are used upon all the figures. A A represents the cheeks or iron frame of the press, being of a curved form, as seen in fig. 2, and supported upon cast iron legs, B B. C C shows the table to receive the form of types; it is composed of a cast iron plate turned and ground perfectly flat upon its upper surface, and strengthened by deep ribs on the underside, two of which ribs are made straight, and serve as guides to slide in grooves upon the upper edge of the rails D D, as seen in fig. 2, for running the carriage backwards and forwards. The carriage is moved by the handle E in the usual manner. G G represent strong brackets which are cast upon the main frame of the press, and serve to support the rails D D, at the part where the pressure is applied. The farther ends of the rails are united by a cross piece, H, seen in fig. 3, from which two small pillars, I, descend to the ground, to support the weight of the carriage when run out. K K shows the platen; it is guided so as to move steadily up and down by the metal frames or bars, L L, being screwed to its upper surface in such manner as to embrace the upper part of the main frame of the press, and slide between small projecting pieces, c c. The bars L L are furnished with spiral springs, which bear upon the top of the frame A A, and serve to balance the weight of the platen, keeping it always clear above the surface of the tympan, when the handle N of the press is left at liberty.

We shall now describe the manner in which the requisite pressure is effected in this press. R and S, figs. 1 and 2, represent two steel cylinders or rollers, having small projecting flanges on each end: the upper roller R, bears against the under surface of an inclined steel plate which is screwed to the projecting part T, of the main frame, and the under roller S, bears upon the upper surface of a similar inclined steel plate screwed upon the upper boss V, of the platen. In this situation a steel wedge is introduced between the rollers R and S, and this wedge is connected by a link W, with the lever or handle N, of the press, as shown in the plate, fig. 3. Now it is evident, that if the steel wedge is drawn forcibly between the rollers R and S, it will roll them along between the two inclined steel plates, and consequently force the plates asunder; and, since one of the inclined plates is fixed to the platen, and the other to the solid frame of the press, the platen will be forced down upon the types placed beneath it. The two small figures Y and Z, representing the rollers, &c. detached from the press, will serve to explain their operation. The rollers R and S, as also the inclined plates T V, and the wedge W, are made of steel, and hardened in the most perfect manner; otherwise, the immense pressure acting upon a mere line of contact upon their surfaces would indent them, and totally destroy their operation. The handle N, moves upon a fixed center of motion, at N, in the projecting part of the frame, Q Q, and the pressure is regulated by lengthening or shortening the connecting link W, which is furnished with a screw in the middle of its length for that purpose. The rails D D, upon which the carriage moves, are furnished with small square pieces of steel placed at regular distances.

Ruthven's Press.

Plate CXII. figures 4, 5, and 6. Fig. 4 on the Plate shows an horizontal plan of the press; fig. 5, a vertical section taken through the middle; and fig. 6, an end view. The same letters of reference are used on all the figures. A A represents the table or surface upon which the form of types is laid. This table is mounted upon a framing of cast iron, consisting of four upright legs, B, strengthened by diagonal braces C. Immediately beneath the table two levers, D E, D E, are situated, moving upon fixed centers or fulcrums, at D D. These levers are jointed to double hooks or clutches F F, so that when the ends, E, of the levers are depressed or drawn down by the links, a (communicating with a third lever G, H, I), the hooks F F are drawn down also, but with a slow motion. The fulcrum of the third lever is at G, and the point H is where the power is applied to actuate it by the connecting-rod K; the opposite end of which is jointed to a crank or short lever, situated upon an axis, L, which extends to the front of the press, and is furnished with a winch or handle N, for the pressman to move it by. M represents the platen. It has a strong metal bar, P, united to it by screws, r r, at the extremities of the bar P: strong iron bolts, d d, are secured by nuts upon their uppermost ends. These bolts have heads or projections formed at their lower ends, which are exactly fitted to the hooks or clutches, F F: by this means the

platen is connected occasionally with the levers D E, D E, and may be brought down upon the types by the pressman turning the winch, N, in the direction shown by the arrow in fig. 5.

By returning the winch N to its original position, the pressure is relieved, and the platen M may be removed from off the types. Thus, at the ends of the bar P, two springs *e e* are affixed, and in the ends of these springs small rollers or wheels are fitted to move freely upon these center pins. These wheels have grooves in their edges, adapted to run upon the angles of two rails R R, which extend on each side of the table A A, and project sufficiently behind the press to support the platen, when pushed back from off the types into the position shown in figures 4 and 6. The springs *e e* are so adjusted, that when the platen moves along upon the rails R R, its under furface will be raised up sufficiently above the tympan to allow it to come into its proper position, to produce the pressure; as shown by the dotted lines in fig. 6; or to go back into its original situation, without meeting with obstruction; but when the hooks F and bolts *d* are united, and the pressure brought on by turning the winch N, the springs yield and permit the platen to press upon the types. The platen in the model originally made by Mr Ruthven was contrived to be brought forward by a treddle; but in the presses since made, it is both brought forward and pushed back by the handle *n*. The centers of motion D D of the great levers, and of the lever G, as well as the pivots L of the winch N, are all supported in one frame, composed of two metal cheeks, which are situated beneath the table, and united thereto by screws, as shown by the dotted lines in the Plan, fig. 4. The lever G H is in the most favourable position to receive the action of the rod K, viz. perpendicular to it; and the lever G I is in a position to exert a greater power upon the links *a*, and levers D E, than when it is in the horizontal position; for when the pressman first takes the handle N, it acts with but little advantage as to power upon the levers, and, therefore, brings the platen down very quickly upon the tympan; but when the handle has arrived near the horizontal position, then the power it exerts to bring down the platen is immensely great. The tympan is jointed to one end of the table in the usual manner.

Bacon and Donkin's Printing Machine.

Plate CXIII. The machine represented in the Plate is furnished with a square prism, marked A, having four surfaces, upon which the types are fixed. The pivots at the ends of its axis are supported in bearings in the frames B B, and it is caused to revolve by a connection of wheelwork D E and F G, from the fly wheel and winch H. The types yield their impression upon the paper by means of the platen I, which is placed immediately beneath the printing prism. The circumference of the platen being formed, as shown at I in the section, fig. 3, applies itself in its revolution to the surface of the types. The ink is applied to the types by the cylinder K, placed above the prism. It is composed of a soft elastic substance upon a metallic cylinder or axis; and, that its surface may always apply to the types, its spindle is fitted in the pieces L, which move upon an axis *n*, so as to allow the cylinder to rise and fall, and thereby accommodate itself to the prism. The inking cylinder receives its ink from a second cylinder M, which is called the Distributing Roller, having also an elastic surface, which is supplied with ink by a third roller N, made of metal, and turned as true and cylindrical as possible. The ink is deposited in quantity against this roller, upon a steel plate O, the edge of which being placed at a very small adjustable distance from the circumference, permits the roller, as it revolves, to carry down upon its surface a thin film of ink, which being taken off by the distributing roller, is applied to the surface of the inking cylinder, which, as before mentioned, inks the types.

The sheet of paper to be printed is introduced to the machine by placing it upon a blanket, which is extended upon a feeding board P, and drawn in at a proper time by having a small rail or ruler *a*, fig. 3, fixed to it; the ends of which are taken forwards by studs *b* attached to endless chains, extending from the wheels *e* (at the end of the platen seen in fig. 1), to other wheels *d*, which are supported in the frame of the feeding board. The wheels *e*, having teeth entering the links of the chains, cause them to traverse and draw the blanket and sheet of paper into the machine. The page or pages of types are composed in the usual manner in gallies, which gallies are attached by screw clamps to the sides of the printing prism, so as to be readily taken off. They are also furnished with adjusting screws to fix them exactly in their proper situations, as shown in the Front Elevation, fig. 1. The two wheels D E, which cause the prism and platen to accompany each other in their revolution, are formed, as shown in fig. 4, to correspond with the prism and platen: thus the upper wheel D, is a square with its angles rounded off, and the geometrical outline is exactly the same as that of the prism. The lower wheel E, is of the same shape as the platen, and its pitch line the exact shape of the surface thereof. These wheels being toothed must revolve together, so that no slipping or sliding can take place between the surfaces of the printing prism and platen at the point of contact.

To regulate the pressure upon the paper, the bearings in which the pivots of the platen are supported can be elevated by screws, and to prevent any derangement of the wheels, D and E, by such adjustment, universal joints are applied in their axes, as shown at R in fig. 1. The inking cylinder is turned round by a cog-wheel V upon the extremity of the axis of the prism, which is the same shape as the wheel D and shapes T. The wheel V communicates motion to a circular wheel W, fixed upon the end of the spindle of the inking cylinder. The wheel W gives motion to the distributing roller M, by a pinion *f*, and this again turns the ink roller N by a third pinion *g*, fixed upon the end of its axis *n*, which is supported upon bearings on the frame B B. The pieces L L, which support the pivots of the distributing roller and inking cylinder, are fitted upon the axis *n* of the ink roller, so as to rise and fall upon it as a center of motion. The steel plate *o* for regulating the supply of ink to the roller N, is supported by a bar

of metal extending across the fixed frame B B, and the ink is prevented from flowing off at the ends of plate *o*, by pieces of metal *p*, which enter a short distance into grooves formed round the ink roller N near its ends. The frame, supporting the feeding board P, is composed of two rails fitted upon round parts of the axis of the platen, and borne up at their outermost ends by a brace from the wood framing of the machine: these rails sustain the pivots of the wheels *d*, as shown at X in fig. 2. The feeding board has two ledges *c* formed along its sides to allow the rulers *a* of the blanket to slide freely upon, in their progress to the types; and the space left between the segments of the platen, as seen at 6 in the section, fig. 3, receives the ruler *a*.

Bensley's Printing Machine.

Fig. 1, Plate CXIV. represents a perspective view of a machine employed in Mr Bensley's printing office, which is moved by the power of a steam-engine. It is supposed to be in the act of printing, being attended by two boys, one of whom is occupied in laying on the blank sheets of paper, and the other in receiving the printed sheets as they quit the machine. Fig. 2 shows a longitudinal section of the machine, to explain the manner in which the paper passes through to receive the impression upon both sides, and also the means employed to apply the ink to the surface of the types. Though all the material motions of the machine are displayed, yet some of the minute parts, which produce the various movements, have been omitted, in consequence of the diminutive scale of the figures, which is only about one-third of an inch to a foot.

The supply of blank paper is laid upon a support or table, A, from whence the sheets are taken, one by one, by a boy standing upon an elevated platform, who lays them out upon the table B, which has a number of narrow linen tapes or girths passing across its surface. These tapes are formed into endless bands, which extend round the cylinders, or rollers C and D, in such a manner, that when the rollers are turned round, the motion of the tapes will carry the sheet of paper along with them, and deliver over the roller E, where it is seized between two systems of endless tapes, passing over a series of rollers to keep them extended. These endless tapes are so adapted, in number and position, as to fall between the pages of printing, and also on the outsides, or beyond the margin of the printing; they may, therefore, remain in contact with the sheet of paper on both sides during its whole passage through the machine; by which means the paper being once received or taken in between the two systems of endless tapes, it will be capable of continuing its motion along with the tapes, in order to bring it into a situation to be printed on both sides, without destroying the register (or coincidence of the pages on the opposite sides of the sheet). F and G represent the two main cylinders which effect the pressure upon the paper. They are mounted upon strong axes, which turn in stationary bearings affixed to the main frame of the machine. H and I are two intermediate cylinders situated upon axes between the main cylinders. Their use is to effect the inversion of the sheet of paper, in order to print the opposite side.

We must now describe the manner in which the two systems of endless tapes before mentioned are arranged, to give a clear idea of the operation of the machine. We will suppose one system of tapes to commence at the upper part of the roller E, from whence they proceed in contact with the under portion of the circumference of the main cylinder F; they then pass over the upper portion of the intermediate cylinder H, and under the intermediate cylinder I, from whence they proceed to encompass a considerable portion of the main cylinder G; and by passing in contact with the rollers *a*, *b*, *c*, *d*, and *e*, they arrive again at the roller E, from whence they commenced; thereby forming one of the systems of endless tapes. The other system we will suppose to commence at the roller *h*. They are equal in their number to the tapes already described, and correspond with them also in their place upon the cylinders, so that the sheets of paper may be securely held between them. The second tapes descend from the roller *h* to the roller E, where they meet and coincide with the first system, in such a manner that the tapes proceed together under the main cylinder F, over the cylinder H, under the cylinder I, and round the main cylinder G, until they arrive at the roller *i*, where they separate; having remained thus far in actual contact, except at the places where the sheets of paper are held between them. From the roller *i* the tapes descend to the roller *k*, and by passing in contact with the rollers *m*, *n*, and *o*, they arrive at the roller *h*, from whence they commenced. Thus the two systems of endless tapes are established and arranged so as to be capable of circulating continually without interfering with each other. The cylinders F, G, H, and I, as also the roller E, are connected by toothed wheels, as represented in the perspective view, fig. 1, so as to cause their circumferences to move with one uniform velocity, and thereby prevent any sliding or shifting of the two systems of tapes over each other during their motion; as much of the perfection of the printing depends upon this circumstance. The separate forms of types for printing the two sides of the sheet are placed at a certain distance asunder upon one long carriage, which is represented in a detached state at fig. 3. This carriage, with the forms of type secured upon it, is adapted to move backwards and forwards upon steady guides or supports attached to the main frame of the machine; in such a position, that the surfaces of the types may be operated upon by the circumference of their respective cylinders F and G, to produce the impression as the carriage moves backwards and forwards. This reciprocating movement of the carriage is effected by a pinion fixed upon the end of a vertical spindle, K, fig. 2, engaging in the teeth of an endless rack, L L, which is connected by a system of levers with the type carriage in such a manner, that when the pinion is turned round, it engages at alternate periods in the teeth formed upon the opposite sides of the rack L L, and consequently on the opposite circumference of the pinion; thereby a continuous motion of the pinion communicates a reciprocating mo-

tion to the rack and carriage; the vertical spindle K is turned by a pair of bevelled wheels from the pinion P, fig. 1, which receives its motion by an intermediate wheel, Q, from the toothed wheel upon the end of the main cylinder G.

The mechanism for furnishing and distributing the ink upon the surfaces of the types in this machine is very ingeniously arranged, and performs its operation with great certainty. It is one of the most important points, and the most difficult to effect in printing machines. Two similar and complete systems of inking apparatus, one situated at each end of the machine, are adapted to ink their respective forms of types; we will therefore describe, by reference to the fig. 2, the inking apparatus situated at the right hand end of the machine. It consists of a cylindrical metal roller, N, which has a slow rotatory motion communicated to it by a catgut band passing round a small pulley upon the end of the axis of the main cylinder G. The roller N is adapted to carry down a thin film of ink upon its circumference, by turning in contact with a mass of ink disposed upon a horizontal plate of metal, the edge of which plate is ground straight, and fixed by screws *r r*, at a small adjustable distance from the surface of the said roller. O represents an elastic composition roller, which is mounted in a frame turning upon an axis, *p*, extending across the main frame of the machine. This roller is connected by cranked levers with a small eccentric circle fixed upon the end of the axis of the cylinder G (as seen in fig. 1), which causes it to move round the axis *p*, and remain for a short period in contact with the surface of the ink roller N (as seen by the position at the left hand end of the machine, fig. 2), thereby receiving a portion of ink upon its surface; it then descends and rests with its whole weight upon the surface of a flat metal plate or table, T, which is affixed to the type carriage, as seen in fig. 3; so that the reciprocating motion of the carriage causes the ink table T to receive ink upon its surface from the elastic roller O. In this situation, when the type carriage returns, the surface of the table T is obliged to pass under three small elastic rollers (seen at R), which are mounted upon pivots in a frame, with liberty of motion up and down, in order that the rollers may bear with their weight upon the surface of the table. The frame in which they are centered has also a slight end motion given to it by the inclined form of the end of the table T (as seen in fig. 3), bearing against a roller fixed upon the said frame. Thus the small composition rollers R operate in a very complete manner to equalize the supply of ink over the surface of the table T, and by the farther motion of the type carriage the ink table is caused to pass under four small elastic rollers (seen at S), which, in like manner, bear with their weight upon the surface of the table (but without end motion), and thereby take up the ink upon their circumferences. The type carriage then returns, for the table T to receive a new supply of ink, and by the form of types passing under the elastic rollers S, the letters become inked in a very perfect and uniform manner. Whilst the operation of inking the types is going on at one end of the machine, the printing is performed at the other end on one of the sides of the sheet from the types last inked, and *vice versa*. The type carriage is caused to move steadily along with the circumferences of the cylinders F and G, by having racks Y Y formed on each side of the forms of types (as seen in fig. 3), which engage with sectors or portions of toothed wheels, *x x*, upon the ends of the said cylinders; at which part the surfaces of the cylinders are covered with a blanket or felt, to give elasticity, and cause them to press equally upon the paper, as in ordinary printing presses.

The machine is put in motion by a strap, *y y*, passing round a pulley, X, as seen in fig. 1, upon the axis of which pulley a pinion is fixed, engaging with the teeth of the large wheel upon the end of the main cylinder G. Thus the various cylinders, with their two systems of tapes, are caused to revolve with an uniform movement in the direction of the arrows (seen in fig. 2), whilst the type carriage travels alternately backwards and forwards upon its guides, as before mentioned. The operation of printing is performed as follows: The sheets of blank paper are laid one by one upon the table B, so as to bear upon the linen tapes which extend over its surface. In this situation the rollers C and D are caused to move a portion of a revolution, by the operation of a lever fixed upon the axis of the roller D, being acted upon by another lever fixed on the cog-wheel of the main cylinder F. This motion advances the sheet of paper sufficiently to enable it to be seized between the two systems of endless tapes at the point where they meet each other, or between the rollers *h* and E. As soon as the sheet of paper is carried clear off the table B, the rollers C and D are caused to turn back again to their original position, by the operation of a weight, W, and cord, *w*, as seen in fig. 2, ready to advance a second sheet of blank paper into the machine. The sheet of paper is carried along between the systems of tapes, and applies itself to the circumference of the main cylinder F, upon the blanket before mentioned; and by the continuous motion of the cylinder, the sheet of paper is pressed upon the surface of the form of types as they pass under the cylinder by the reciprocating motion of the carriage. By this means one of the sides of the sheet receives its impression at the same time the form of types situated at the opposite end of the carriage is receiving its ink, as before described. Now, by the continuous motion of the machine, the sheet of paper advances in company with the endless tapes round the intermediate cylinders H and I, until it applies itself to the blanket upon the surface of the main cylinder G; at which place it will be found in an inverted position, so that the printed side of the sheet is in contact with the blanket and the blank side of the sheet downwards, which, upon meeting with the other form of types at the proper instant, is pressed upon their surface sufficiently to produce the impression. Thus having arrived at the point *i*, where the two systems of tapes separate, the printed sheet is delivered upon the board Z, where it is received by a boy, and laid upon the pile.

Fig. 2.

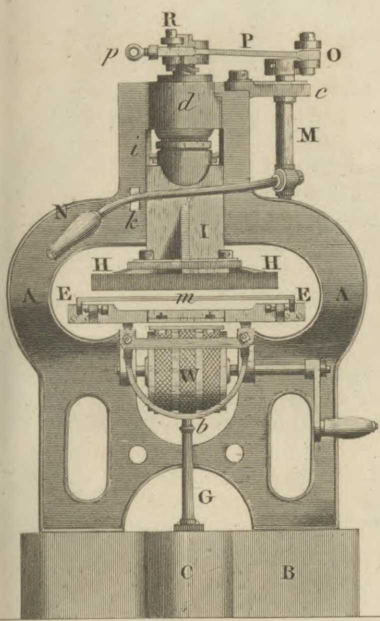


Fig. 1.

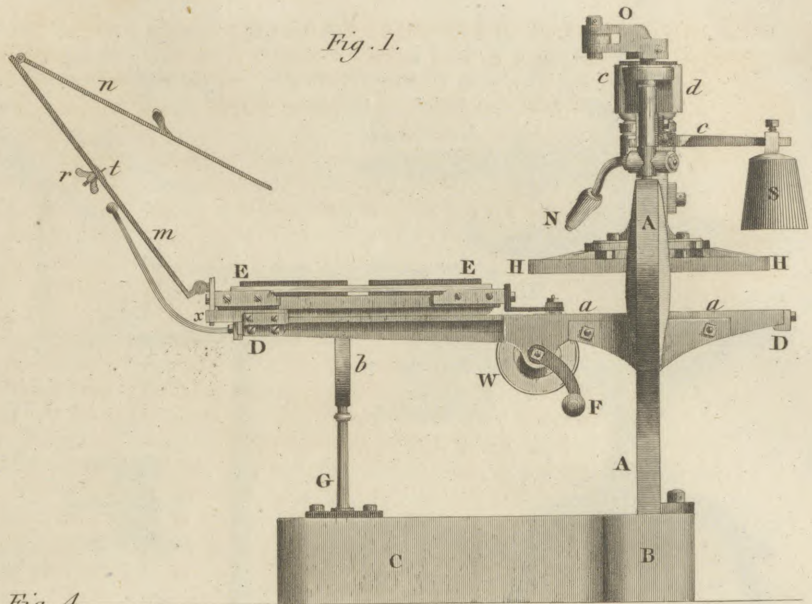


Fig. 4.

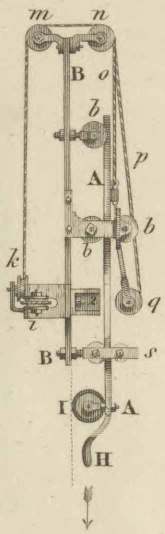


Fig. 3.

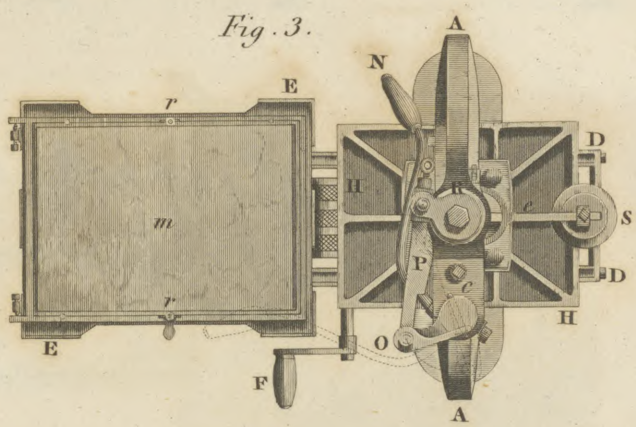


Fig. 5.

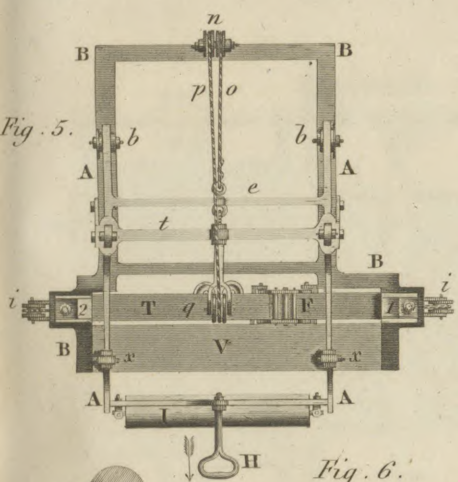


Fig. 6.

Fig. 8.

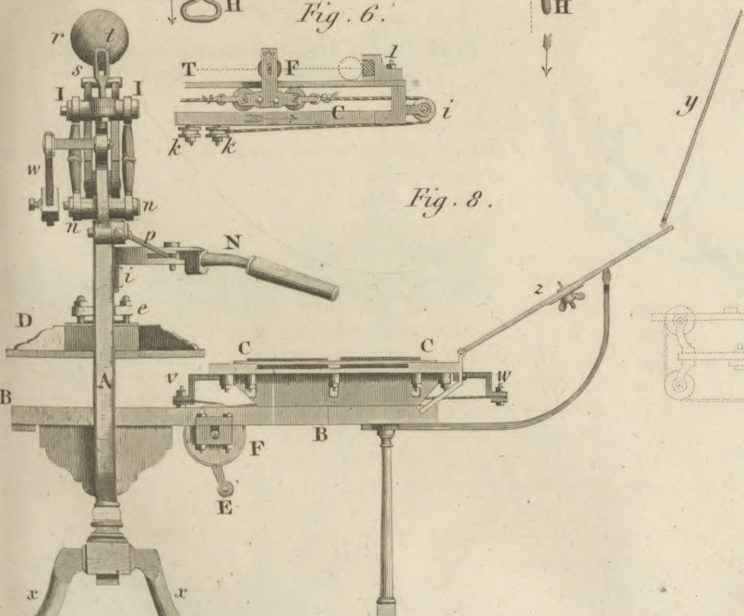
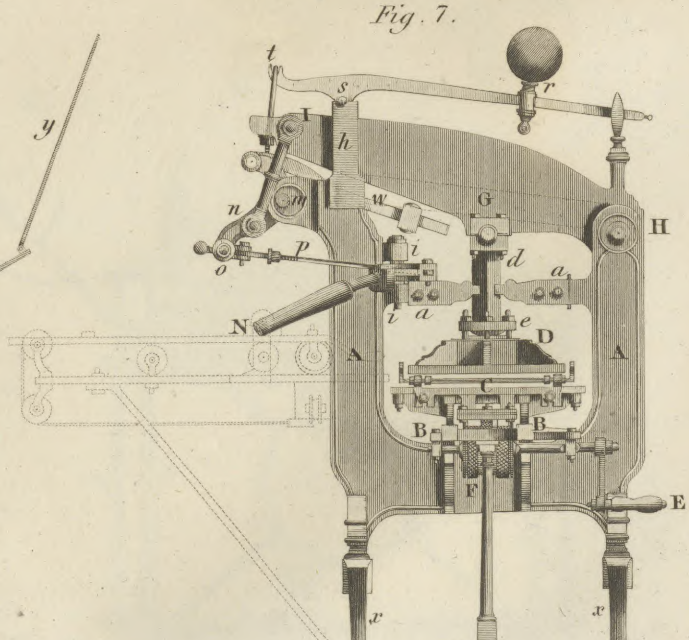
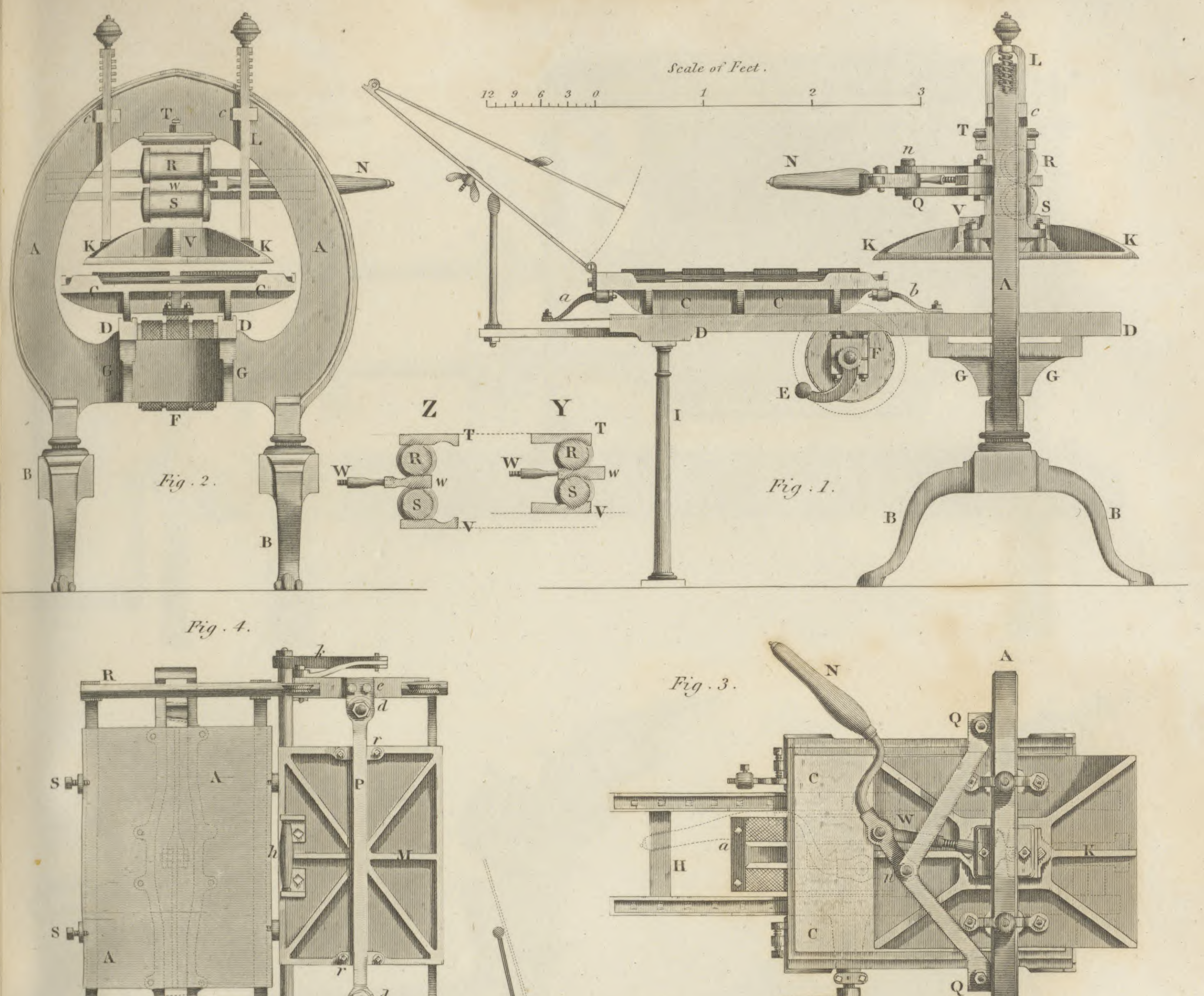


Fig. 7.





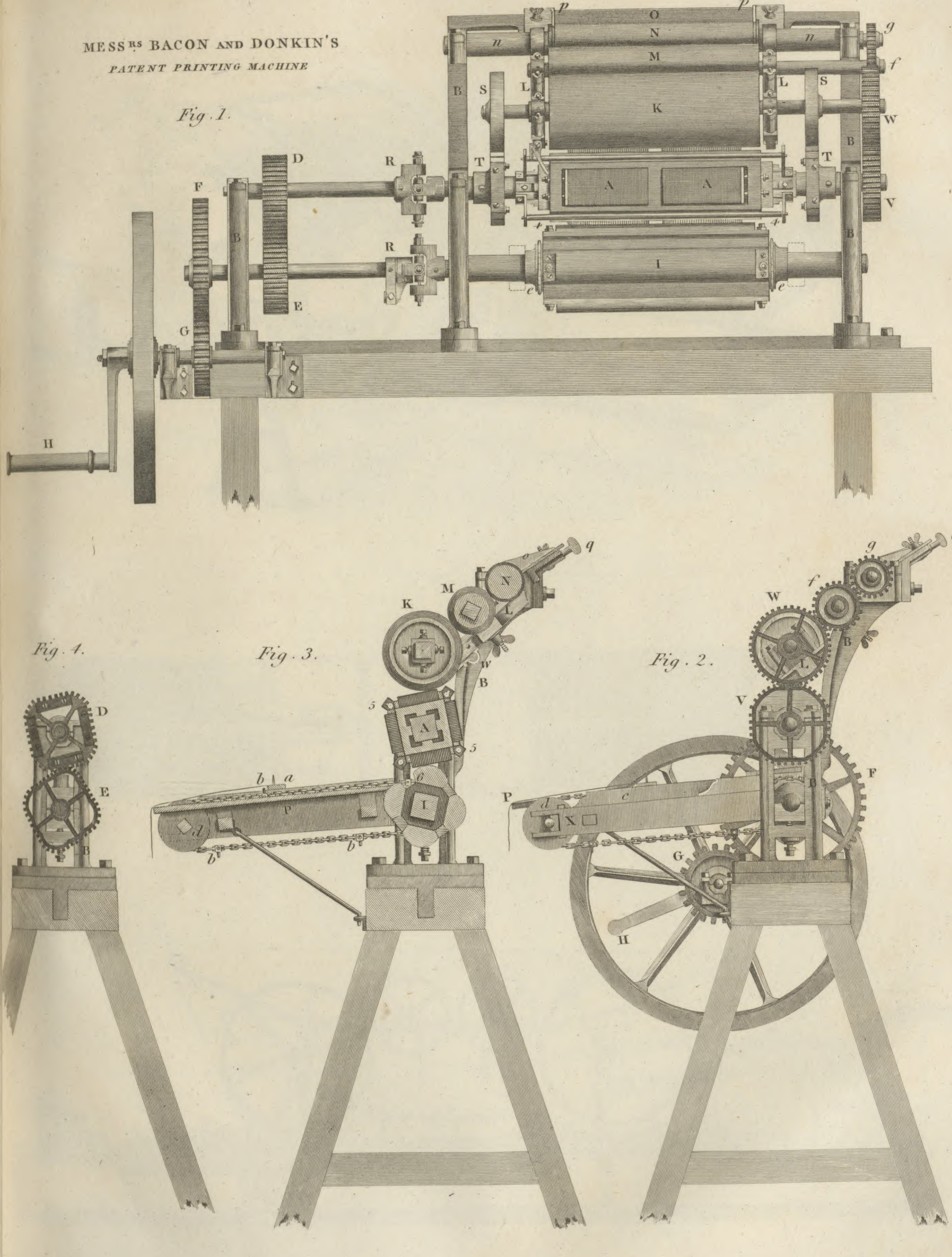
Jas. Farey delt.

Published by A. Constable & Co. Edinr. 1823

W. Archibald sculpt.

MESSRS. BACON AND DONKIN'S

PATENT PRINTING MACHINE



Farey delt. Published by A. Constable Co. Edinr. 1823 W. Archibald sculpt.

Fig. 1.

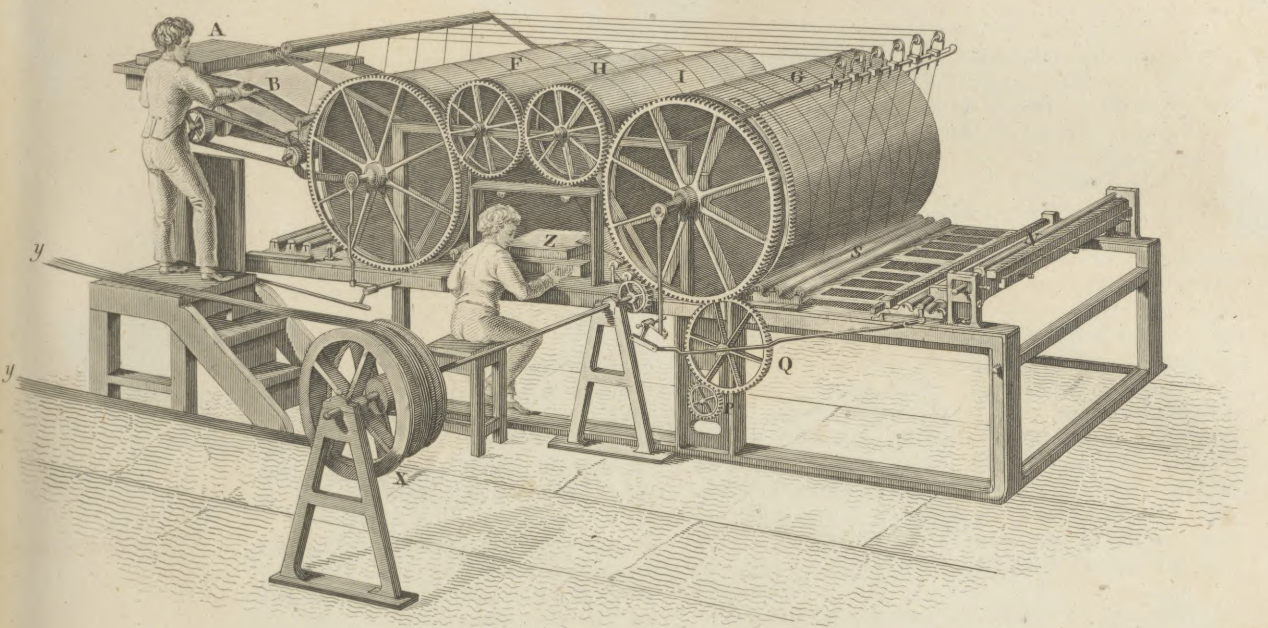


Fig. 3.

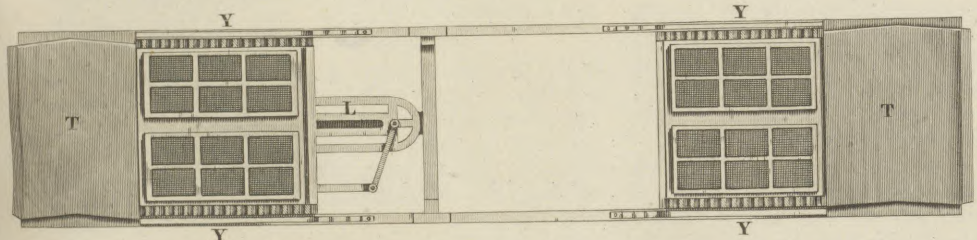
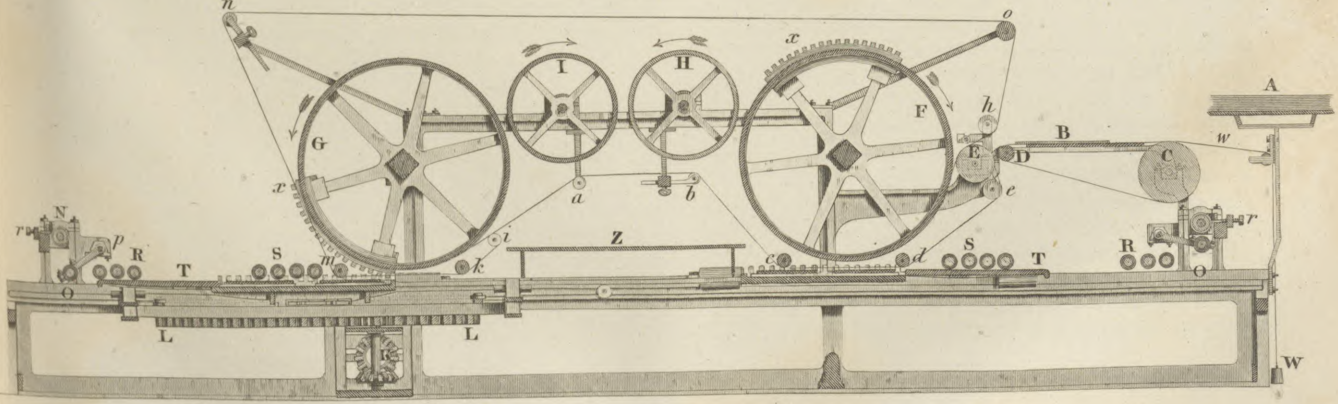


Fig. 2.



Jos. Farey del.t Published by A. Constable & Co Edin.r 1823. W. Archibald sculp.t

PRISONS AND PRISON DISCIPLINE.

The arrangements, necessary to adapt prisons to the ends for which they are designed, seem to require little more than the exercise of practical good sense; and yet the manner in which the practice of the world blunders on from one absurdity, and very often from one atrocity, to another, shows pretty distinctly, how little the public affairs of mankind have hitherto had the benefit of that practical faculty, or of any thing that resembles it.

Ends of Imprisonment.

Prisons have been applied to three purposes; *1st*, That of safe custody; *2dly*, That of punishment; *3dly*, That of reformation.

It is very evident, that each of these purposes requires an arrangement of means peculiar to itself.

Though each requires a combination of means peculiar to itself, it does not follow that, of the means required for each, a portion may not be the same in all. Every body will acknowledge that this is the case.

The means of safe custody, for instance, are equally required for those who are imprisoned in order to be punished and those who are imprisoned in order that they may be reformed, as for those who are imprisoned to the sole end of being made present at a particular time and place.

The arrangements, then, for safe custody, form a basis, on which every combination of means for attaining any of the other ends of imprisonment must always be erected. Other means for the attainment of these ends are to be considered as accessions to those required for the first.

It is a corollary from this position, that the same house may, at one and the same time, be employed for all the three purposes. Those properties in the building which make it fittest, at the least expense, for safe custody, make it fittest also for the purposes either of punishment or of reformation. This will be rendered abundantly apparent in the sequel; and from the single circumstance, that the means of punishment and reformation are only additions to those of safe custody, it wants not much of its demonstration already. If the arrangements needed, for those who are to be punished, and those who are to be reformed, interfere not with one another, or with those needed on account of the persons in safe custody merely, the truth of the corollary is indisputable; for nobody will deny that, in point of economy, there must be very great advantage.

Means of safe Custody.

I. We shall consider, first of all, what is the best combination of means for safe custody. Dungeons and fetters are the expedient of a barbarous age. And in respect of prisons, as of every thing which comes within the precincts of law, the expedients of a barbarous age are, with great industry, retained in those which are civilized; they are, indeed, not only retained with great industry, but preserved with a success which, if it were not experienced, would be altogether incredible. As the expedients of a barbarous age are still preserved in many more of the arrangements for the purposes of law, so it is but of yesterday that the prisons of our forefathers have been regarded as fit for reform, or the means which in their ancestorial wisdom those sages devised for attaining the ends of imprisonment were supposed capable of being altered for the better, by their less instructed sons.

It is at last, however, allowed, that inspection is a means for safe custody, which renders unnecessary all but very ordinary means of any other description. Thus, so long as a man is, and knows that he is, under the eyes of persons able and willing to prevent him, there is very little danger of his making an attempt, which he sees would be vain, to effect a breach in the wall, or force open the door, of his cell. Any great strength, therefore, in such wall or door, as well as fetters upon any part of his body, the object of which is to make provision against such attempts, are wholly unnecessary; since the attempts are sure of not being made, or of being instantly frustrated.

The plan of a prison, in which the power of inspection is rendered so complete, that the prisoner may be, and cannot know but that he is, under the eyes of his keepers, every moment of his time, and which we owe to General Bentham, so universally known for his mechanical genius, is described by his brother, in his work entitled *Panopticon, or Inspection House;* where also a system of management is delineated, and its principles are so perfectly expounded, and proved, that they who proceed in this road, with the principle of utility before them, can do little else than travel in his steps.

An idea of the contrivance may be conveyed in a few words. It is a circular building, of the width of a cell, and of any height; carried round a space, which remains vacant in the middle. The cells are all open inwards, having an iron grating instead of a wall, and, of course, are visible in every part to an eye properly placed in the vacant space. A narrow tower rises in the middle of that space, called the inspection tower, which serves for the residence of the keepers, and in which, by means of windows and blinds, they can see without being seen; the cells, by lights properly disposed, being capable of being rendered as visible by night as by day.

We have thus provision for safe custody; and along with it, five other important purposes are gained. First of all, there is great economy; the vast expense of thick, impenetrable walls, being rendered unnecessary. Secondly, All pretence for subjecting prisoners to the torture and degradation of irons is taken away. Thirdly, No misbehaviour of the prisoners can elude observation, and instant correction. Fourthly, No negligence, or corruption, or cruelty, on the part of the subordinate agents in the prison, can escape the view of their principals. And, Fifthly, No misconduct towards the prisoners, on the part

Prisons and Prison Discipline.

of their principals, can remain unknown to the public, who may obtain a regulated admittance into the inspection tower, and regulated communication with the prisoners.

The persons who are liable to be in prison, for sure custody merely, are of three classes. First, Persons apprehended, and about to be put on their trial, for the commission of a crime. Secondly, Persons convicted of a crime, and about to receive their punishment; and, Thirdly, Debtors.

Under a good system of law, very little provision would need to be made for these cases. It is one of the essential properties of a good system of law to permit as little time as possible to intervene between the apprehension and trial, and between the conviction and punishment, of a person for a crime. There would never, therefore, be many such persons in any prison at a time. And under a good system of law, there never would be any body in a prison on account of debt.* This is mentioned merely to show how little, under a good system of law, the apparatus and expense of a separate prison, for this set of cases, would be wanted.

These persons being inmates of a prison, for insuring their presence merely, the question is, What treatment they ought to receive?

Persons in prison before trial, and debtors, are persons of whom nothing is certainly known, but that they are unfortunate. They are, therefore, entitled to all the benevolence which is due to the unfortunate.

What is done for them in a prison must, however, be done at the expense of the community, that is, by sacrifices demanded of those who are not in prison; and those sacrifices ought, undoubtedly, to be the smallest possible. The question is, therefore, to be settled by a compromise between the principle of benevolence, and the principle of economy.

The principle of benevolence undoubtedly requires that the health of the prisoners should not be impaired; for this, importing the premature loss of life, is in reality the punishment of death, inflicted upon those to whom no punishment is due.

That health may not be impaired, three things are indispensable:—1. A wholesome apartment; 2. A sufficiency of wholesome food; 3. Sufficient clothing.

The principle of economy, with equal certainty, exacts, that all those should be of the cheapest possible kind.

All this is abundantly clear. It is equally clear that, with respect to those who are in prison for safe custody merely, the principle of benevolence requires, and the principle of economy does not forbid, that they should be free to use any indulgence, which costs nothing, or which they provide for themselves; and that no farther restraint should be placed upon their liberty than the custody of their persons, and the rule of economy, which prescribes the limits and accommodations of the place, may demand.

Prisons and Prison Discipline.

Few words will be necessary to show what is appropriate to the case of the man, who is in prison during the interval between his sentence and his punishment.

By the supposition, in this case, his punishment is something distinct from his imprisonment; because, if not, it is a case which comes under another head, namely, that of persons who are in prison for the sake of punishment; and will be fully considered in another part of this discourse.

If he is in prison for detention merely, his punishment, as meted out and fixed by the judge, being something wholly separate; every particle of hardship, imposed upon him, not necessary for his detention, is something without law, and contrary to law; is as much injustice and a crime, when inflicted upon him, as if inflicted upon any other member of the community. The same considerations, which, as we found above, ought to regulate the imprisonment of debtors, and persons in custody before trial, namely, the compromise between the principle of benevolence and the principle of economy; apply, without the smallest difference, to the case of persons who, during the interval between their sentence and its execution, are in prison for the mere purpose of preventing their escape.

We foresee a difficulty, or rather an objection, for there is really no difficulty in the case.

Persons come into prisons, who have been accustomed, in the preceding part of their lives, to all degrees of delicate and indulgent living; to whom, therefore, the hard fare prescribed by the principle of economy will occasion very different degrees of uneasiness.

Such persons, when in prison for safe custody merely (what is required when persons are in prison for punishment, or for reformation, will be seen hereafter), may be allowed to make use of any funds which they may possess for procuring to themselves all unexceptionable indulgences. They may be also allowed the exercise of any lucrative art, consistent with the nature of the prison, for procuring to themselves the means of such indulgences. This the principle of benevolence dictates, and there is nothing in the principle of economy which forbids it.

We shall be told, however, that there are persons, who have been accustomed to a delicate mode of living, and who come into prison without the command of any funds, or the knowledge of any art, by which they may soften the hardship of their lot: and we shall be asked what is the course which our philosophy recommends for the treatment of them? The course which it recommends is very clear. Such persons are paupers, and whatsoever treatment is fit for paupers of the description to which they belong, is fit also for them. If there are

* If evident fraud were committed in contracting the debt, or if the property of others obtained by loan, had evidently been dishonestly spent, or dishonestly risked, such fraud, or dishonesty, being crimes, not a debt, might justly subject a man to imprisonment, or any other sort of due punishment.

Prisons and Prison Discipline.

any funds, to which as paupers they can apply, the application should be open to them. If there are none, and there is no person to whose benevolence they can resort, the effects of such a destitute situation must be sustained, the same way in a prison, as they must be, when any person falls into it, out of a prison.

Means of Punishment.

II. Having stated what appears to us necessary for illustrating the principles which ought to regulate the imprisonment of those, in respect to whom safe custody is the end in view, we come, in the next place, to the case of those, in respect to whom, in addition to safe custody, punishment is to be effected through the same medium.

This subject we shall unfortunately be under the necessity of treating superficially; because, in order to explain it fully, we ought to have before us the whole doctrine of punishment; and, for this purpose, a developement, too extensive for the present purpose, would be required.

This we may assume as an indisputable principle; that whatever punishment is to be inflicted, should be determined by the judge, and by him alone; that it should be determined by its adaptation to the crime; and that it should not be competent to those to whom the execution of the sentence of the judge is entrusted, either to go beyond the line which he has drawn, or to fall short of it.

We have already established, on what seemed sufficient reasons, that for persons confined, on account of safe custody merely, the cheapest accommodation, not importing injury to health, in respect to apartment, food, and clothing, should alone be provided at the public expense.

Unless in the case of those whom the judge might condemn to lose a portion of their health, as the punishment due to them, by the sufferings of an unwholesome prison, unwholesome food, or improper clothing, this accommodation ought to be afforded even to those who are placed in prisons for the sake of punishment. And if it should be thought that the loss of health never can be a proper punishment, if it has never been regarded as such even by savages, and is repudiated by every principle of reason, then it follows, that the accommodations which we have described in the former part of this discourse, as required in the case of prisoners detained for safe custody, are required in the case of prisoners of every description.

This is a basis, therefore, upon which every thing is to rest. In every rational system of prison management, this is an essential condition. We are now to see in what manner, upon this footing, punishment, by means of imprisonment, is to be effected.

One mode is sufficiently obvious and sufficiently known. The punishment may be rendered more or less severe by its duration. Want of liberty is, in almost all cases, a source of uneasiness; want of liberty, added to the denial of all pleasures of sense, can hardly ever fail to be a source of great uneasiness. A long imprisonment therefore, with the cheapest accommodation not importing injury to health, must be a severe punishment. This, it is evident, may be graduated to more or less of severity, not only by degrees of time, but the use of such means as the prisoner might command for procuring accommodations and indulgences.

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To this imprisonment may be added solitude. But though we mention this, as a practicable addition to simple imprisonment, it is well known how little, unless for short periods, and on very particular occasions, it is to be recommended.

The modes, which lately have been most in repute, of adding to the severity of simple imprisonment for the purpose of punishment, have been two; 1st, Hard labour; and, 2dly, Bad prisons, and bad management in those prisons.

1. The species of labour which appears to have obtained the preference is that of treading in a wheel.

If a criminal in a prison is ever to be let out again, and to mix in society, it is desirable that nothing should be done, and least of all done on purpose, to make him a worse member of society than when he went in. There cannot be a worse quality of a punishment, than that it has a tendency to corrupt and deteriorate the individual on whom it is inflicted; unless, indeed, he is a prisoner for life; in that case, people of a certain temper might say, that making worse his disposition is a matter of little importance; and to them we have no time to make any reply.

Most of those persons who come into prison as criminals, are bad, because they have hated labour, and have had recourse to other means than their industry of attaining the supply of their wants and the gratification of their desires. People of industry, people who love labour, seldom become the criminal inmates of a prison.

One thing, however, is pretty certain, that men seldom become in love with their punishments. If the grand cause of the crimes which have brought a man to punishment is his not having a love but hatred of labour; to make labour his punishment, is only to make him hate it the more. If the more a man hates labour, the more he is likely to act as a bad member of society; to punish a man with labour, and then to turn him out upon society, is a course of legislation which savours not of the highest wisdom.

Besides, in treating labour as an instrument of punishment, call it *hard* labour, if you will, what sort of a lesson do you teach to the industrious and laborious class, who form the great body of your people? to those whose lot is labour, whose lot is hard labour, harder than any which it is in your power to impose? What compulsory labour is so hard as many species of voluntary labour?

As an instrument of reformation, labour, as we shall presently see, is invaluable. As an instrument of punishment, hardly any thing can be conceived more exceptionable. That which is the source of all that mankind enjoy, that which is the foundation of every virtue in the most numerous class of the community, would you stamp with ignominy and dishonour, by inflicting it as a punishment upon the worst and basest of your people? Is this your expedient for rendering it, what every wise legislator would wish to render it, honourable, and thence desirable?

There are other objections, perfectly decisive, against labour as a punishment. It operates with more inequality than almost any other instrument of punishment that ever has been invented. The same degree of labour would kill one man, that to another would be only a pastime. From this source we may apprehend the most horrid abuses, in the continuance of those tread-mills. We may be very sure, that the most atrocious cruelty will often be inflicted upon those who, with strength below the average standard, are placed in those penal engines; while, in the case of those whose strength is much above that standard, they will hardly operate as a punishment at all.

It is impossible that the judge can measure out this punishment; because the judge has not the means of ascertaining the relative strength of the parties who come before him. It must, therefore, be left to the jailor. The jailor, not the judge, will mete out and determine the degree of suffering which each individual is to undergo. The jailor, not the judge, is the man who adapts the punishment to the crime. Hence one of the stains which mark a careless and stupid legislation.

It is a far inferior, though still no inconsiderable proof of a blundering legislation, that the labour, if labour it must be, is not of such a sort as to be useful. The turning of a wheel, by human labour, when so many better means of turning it are possessed in abundance, is destitute of even this recommendation. It stands upon a similar footing with the contrivance of the jailor, whom Mr Bentham celebrates: "We are told somewhere," he says, "towards the close of Sully's *Memoirs*, that for some time after the decease of that great and honest minister, certain high mounts were to be seen at no great distance from his house. These mounts were so many monuments of his charity. The poor in his neighbourhood happened to have industry to spare, and the best employment he would find for it was, to remove dirt from the place where it lay to another where it was of no use. By the mere force of innate genius, and without having ever put himself to school to learn economy of a French minister, a plain English jailor, whom Howard met with, was seen practising this revived species of pyramid architecture in miniature. He had got a parcel of stones together at one end of his yard, and set the prisoners to bring them to the other: the task achieved, Now, says he, you may fetch them back again. Being asked what was the object of this industry, his answer was, 'To plague the prisoners.'"—In a note on this passage, Mr Bentham says, "I beg the jailor's pardon; what is above was from memory; his contrivance was the setting them to saw wood with a blunt saw, made blunt on purpose. The removers of mounts were a committee of justices."

2. Bad prisons, and bad management in these prisons, is a mode of punishment, the recommendation of which has lately been revived, after we might have hoped that, in this country at least, it was exploded for ever. The language of such recommendation has, on several recent occasions, been heard in Parliament; and an article on Prison Discipline, which lately appeared in the *Edinburgh Review*, cannot be interpreted in any other sense. Even the Committee of the *Society for the Improvement of Prison Discipline* have not been able to withstand the force of what they may have supposed to be fashionable doctrine. In their *Fourth Report*, lately published, which we are sorry to say evinces more of good intention, than of enlightened views for its guidance, they say; "No charge can be more mistaken and unfounded, than that the plans recommended by this institution are calculated to introduce comfort into gaols. The committee are of opinion, and have always contended, that severe punishment must form the basis of an effective system of prison discipline;" thereby confounding two things, punishment, and prison discipline; which are totally distinct; and between which, it is of so much importance to preserve the distinction, that without it not a rational idea can be entertained about either.

No doubt crimes must be punished. Who needs instruction upon that head? But when the judge has prescribed, that, in a particular way, which he points out, a particular measure of pain shall be inflicted upon an individual; and when the individual is taken, and made to sustain the operations through which the pain is generated; what has this to do with the discipline of the prison? It is an act or series of acts, *sui generis;* acts not forming any part of the ordinary course of prison management; acts which would not have taken place, which ought not to have taken place, if the judge had not commanded them, and which were performed solely and exclusively in obedience to his commandment. This is the nature of punishment,—other punishment than this there ought to be none.

The Committee would make severe punishment the basis of prison discipline! What business have the Committee with punishment? The assigning of punishment the legislature have given to other and fitter hands; to those who take cognizance of the offence, and alone ought to measure the punishment. Saying they would make punishment the basis of prison discipline, what do they intend by this ill-contrived expression? Do they mean, that their jailor shall hold the scales, and weigh out the proper quantity? If not, how are they to be understood? for if not the jailor but the judge is to weigh, and the jailor is to do nothing but punctually carry the prescription of the judge into execution, then is punishment, in no proper sense of the word, any part of prison discipline. It is a separate operation, performed on a particular occasion, because prescribed by the judge, and in the exact manner in which the judge has prescribed it. If it is, on the other hand, a part of prison discipline, then all the horrid consequences, inseparable from making the jailor the judge and meter of punishment, present themselves to the imagination; and he who can endure to look at them may dwell upon the picture of a prison, wherein the poor will not be more comfortable than at home, nor by the charms of imprisonment enticed to the commission of crimes.

Nothing can more clearly indicate that state of mind, which consists in confusion of ideas, than

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the vague language which we hear about the necessity of making prisons the seats of wretchedness, that crimes, they say, may not receive encouragement.

We have already seen, that, unless it is part of a man's punishment, expressly ordained, that he shall lose a portion of his health; that is, that his life shall be cut short; that is, that after a period of torture, he shall receive a capital punishment; a wholesome apartment, a sufficiency of wholesome food, proper clothing, all of the cheapest kind, must be provided for every body. When people talk about making prisons seats of wretchedness, do they mean something worse than this?

Many of them will no doubt answer; Yes, we mean hard labour in addition. We ask again, Do you mean hard labour, according to the prescription of the judge, or without the prescription of the judge? If according to the prescription of the judge, the case is the same with that which we have previously examined. This instrument of punishment is exceptionable, only because it is a bad instrument.

The whole matter evidently comes to this. If more wretchedness is desired than what is implied in confinement under the worst accommodation which the preservation of health admits, it must be meted out, either at the pleasure of the jailor, or the pleasure of the judge. The writer in the *Edinburgh Review*, and the Committee of the Society for the Improvement of Prison Discipline, speak as if they had never reflected upon the difference.

We do not mean to bestow a word upon that theory, which, for the prevention of offences, would make prisons scenes of wretchedness at the pleasure of the jailor.

The only question which can deserve a solution is, what mode of inflicting evil in a gaol can the judge make use of for best attaining the ends of punishment? The answer is not difficult. Unless, where that course of reformatory discipline, which we shall delineate under the next head, suffices; and we allow, that, though it may be made to involve no small degree of punishment, there are cases in which it would not suffice; it will certainly appear, that prisons are not the best instruments of punishment.

A single consideration suffices for the proof of this proposition. Punishment in a prison loses the grand requisite of a punishment, that of engendering the greatest quantity of terror in others, by the smallest quantity of suffering in the victim. The principal, perhaps the sole end of punishment, is to restrain by the example; because, with respect to the individual whom you have got, if you think society in any danger from him, you can keep him in sight, and no more is required. Yet, the language we hear about the tread-mill, and hear from the mouths of high persons, implies, that hardly any thing more is in their minds, than the effect upon the individual sufferers. "Nothing finer than the tread-mill; a fellow who has been in the tread-mill never comes back again." Be it so; but by your leave, this is a very insignificant part of the question.

The choice of expedients, for obtaining the punishment best adapted to the several cases for which a course of reformatory discipline does not suffice, belongs to another head of inquiry, and must, for the present purpose, be regarded as determined. All that it is necessary for us to show here is, that a prison is not the proper scene for it, nor the instruments of a prison the proper instruments. To render a punishment the most efficacious in accomplishing the great end of punishment, it must be a punishment calculated to make the strongest impression upon the senses, and, through the senses, upon the imagination, of the public at large; more especially of that part of the public who lie under the strongest temptations to the commission of similar crimes. But the punishments inflicted in a prison are withdrawn from the senses of the public, and seem as if they were intended to make the smallest possible, not the greatest possible, impression upon the imaginations of those who are to be deterred from crime. They are defective, therefore, in the most essential quality of a punishment, and can always be supplied by better means of attaining the same end.

The proper idea of a prison is that of a place of custody, and that alone. This idea ought to be clearly, and distinctly, and steadily preserved in the mind, in all disquisitions respecting prison discipline. Punishment and reformatory discipline may be annexed to safe custody; and in as far as they consist of a series of operations, requiring time for their performance, it is essential to them. As reformatory discipline consists wholly in such a series, imprisonment is a necessary condition of it. Since many, also, of the best kinds of punishment are not such as can be executed all at once, but require a period of time, imprisonment is equally necessary for these punishments. But though you must have safe custody to enable you to execute certain punishments, and also to enable you to carry into effect a course of reformatory discipline, safe custody is not the same thing with punishment, nor the same thing with reformatory discipline; and no conclusions can be depended upon, in which ideas so distinct are confounded.

Reformatory Discipline.

III. Having thus considered prisons, as instruments of safe custody, and as instruments of punishment; two of the purposes to which they have been applied as means; it remains, that we consider them, as instruments of reformatory discipline, the third of the purposes to which they have been applied.

It is necessary, first of all, to state a clear idea of reformatory discipline.

When offences, against which it is necessary that society should have protection, are committed, it is desirable that the punishment of the offender should have three properties; 1*st*, That it should deter all other persons from committing a similar offence, which is its most important property. 2*dly*, That it should have the effect of deterring the man himself from a repetition of the offence. 3*dly*, That it should have the effect of removing his former bad habits, and planting useful habits in their stead. It is this last property which is sought to be communicated to his punishment by reformatory discipline.

As the creating and destroying of habits is the work of time, and as the restraint of safe custody, and restraint from all indulgences, except under certain conditions, are necessary to reformatory discipline, whatever punishment is involved in such protracted

coercion, is a necessary part of reformatory discipline.

What is desired is, to create a habit of doing useful acts, in order to break the habit of doing hurtful acts. To accomplish this, means must be obtained of making the individual in question perform certain acts, and abstain from the performance of certain other acts.

The means to be employed for producing performance cannot be of more than two sorts; the pleasurable, and the painful. A man may be induced to perform certain acts, either by punishment, or reward. He may be made to abstain from performing certain acts by an additional means, by withholding the power of performing them.

The latter is the means chiefly applicable for preventing the performance of hurtful acts in prisons; not only crimes, but acts of intemperance, gaming, or any others, the tendency of which is towards crimes. As this is nearly the universal practice, the reasons of it must be so generally known, as not to need developement.

The inquiry which chiefly calls for our attention is, What are the best means of producing the performance of those acts, the habit of performing which we desire to render so perfect, that it may be relied upon for the effect, even in a state of freedom?

The persons on whom reformatory discipline is intended to operate, belong to the class of those who depend upon their industry for their support. So nearly, at least, do they belong to this class exclusively, that the immaterial exceptions may, in this general inquiry, be omitted.

The necessary foundation, in the case of such persons, not only for all virtues, but for abstinence from crime, is the habit of performing some one of those series of acts, which are denominated lawful industry, and for which the performers obtain payment or reward.

Labour, therefore, in some of its useful branches, is to be regarded as the foundation of all reformatory discipline. But as the object of this discipline is to train the man to love, not to hate labour, we must not render the labour in such a case any part of his *punishment*. The labour must, for this important purpose, be a source of pleasure, not of pain.

The way in which labour becomes agreeable to men out of a prison, is the way in which it can be made agreeable to them in a prison; and there is no other. Advantages must accrue from the performing of it.

The way of attaching to it advantages the most intensely persuasive, in a reformatory prison or *Penitentiary*, is exceedingly obvious.

There it is easy to prevent the attaining of any pleasure, except through the medium of labour.

What is provided in the prison, according to the principles already explained, is lodging, food, and clothing, all of the very cheapest kind not producing injury to health. In the monotony of a prison, there is no one who will not intensely desire pleasure in addition to this.

In the sentence of a criminal, who is subjected to reformatory discipline, it may, and as often as the case requires, it ought, to be rendered a part, that he shall not be permitted to make any additions to this hard fare from any source belonging either to himself or others, except his labour; but that what he earns by his labour he may, in a certain way, lay out to procure to himself better food, or any other indulgence (certain hurtful ones excepted) which he may desire. Few cases, indeed, will be found in which this simple contrivance will not produce steadiness of application.

We have now then attained what is of principal importance. For if we have got the inmates of a prison to labour steadily in some useful branch of industry, to look to labour as the great or only source of their enjoyments, and to form habits of so doing, sufficiently confirmed to be depended upon for governing their conduct in a state of freedom, we have prepared them for being useful members of society, and our purpose is accomplished.

Here, then, comes the question, By what arrangements, in detail, can the business of confining, maintaining, and setting offenders to work, be most advantageously performed?

In other words, In what hands should the government of Penitentiaries be placed, and under what rules should it be ordained for them to act?

It is an universal axiom in morals, that no security is equally to be depended upon for any desirable result, as the interest of those upon whom its accomplishment depends. If, in devolving upon a man the task of bringing about a particular end, we make it his interest to bring it about in the best possible manner, especially if we make it his interest in any high degree, we can hardly be disappointed in counting upon his most strenuous exertions. On the other hand, if he has no interest, or a very inconsiderable interest, in the end which he is entrusted to bring about; if little cognizance will be taken of his proceedings, whether good or bad; if to attend to the business would be exceedingly troublesome, to neglect it will produce little inconvenience; we may be very sure that, by a great majority of men, the business of the task devolved upon them will be very imperfectly performed. If they can make a profit out of oppression, or if, as is the case, to so great a degree in prisons, they can consult their ease by imposing additional and mischievous restraints upon the prisoners, their interests are strongly set against their duties, and ill conduct is still more perfectly secured.

This last, how deplorable soever the confession, is the state of management of all British prisons, with hardly any exception. There is a Jailor, who receives a salary and power; and is told to manage the prison well; and there is a number of Justices, that is, gentlemen of the neighbourhood, who obtain not a little power, and a great deal of praise, for undertaking to do certain public duties of a local nature, with little interest in doing them well, and no little interest in doing them in many respects exceedingly ill, who have the charge of looking after him. Varieties we cannot afford to particularize. This is the general description.

The management, then, of the prison, is the joint concern of the jailor and the justices, or magistrates, including sheriffs, who, jointly or severally, have no such interest, as can be expected generally to pro-

duce any considerable effect, in any thing more than such a kind of management as will not excite attention and indignation by its badness. All the degrees of bad management, which are within those limits, having little or no interest to prevent, they have abundant interest to permit.

It is surely not necessary, that we should go far into the detail of this case, to show the causes which it places in operation, and their natural effects.

First of all, it is sufficiently evident, that the jailor has an interest in obtaining his salary, and other emoluments, with as little trouble to himself as possible.

It is not less evident, that the magistrates have an interest in getting the power and credit, attached to their office, with as little trouble to themselves as possible.

This is enough. The book of human nature is clear upon the subject. This principle, at uncontrolled work in a prison, is perfectly sufficient to generate all the evils which those abodes of misery can be made to contain.

It is undeniable, that so far as those, who thus have the superintendence of jailors, are disposed to consult their ease, and to perform negligently a troublesome duty, which they may perform well or ill, just as they please, so far they will be indisposed to listen to any complaints against the jailor. It saves them a good deal of trouble to confide in the jailor. They speedily come, therefore, to look upon confidence in the jailor, and to speak of it, as a good thing,—a duty. "Has not the jailor been most carefully and judiciously selected for his office, by wise and good men? (viz. ourselves). Would it not be an injury to a man of his character to distrust him? And to distrust him—for what? For the complaints of prisoners. But prisoners are always complaining, always giving trouble. Jailors are a good set of men. Prisoners are a bad set of men; especially complaining prisoners. They are the very worst kind of men;—they are, therefore, to be silenced; and it is often very difficult to silence them; nothing but harsh measures will do it; when harsh measures, however, are absolutely necessary, it is the duty of jailors to use them, and the duty of magistrates to protect such men in the discharge of so important a duty."

Such are the feelings and conclusions which are undeniably prompted, by the mere love of ease, in the bosoms of such men as English magistrates.

So far as the magistrates consult their ease (men generally do consult their ease when they have not a preponderating motive to the contrary), the jailor is at liberty to consult his ease.

In the jailor's consulting his ease, every thing that is horrid in a prison finds its producing cause.

What the jailor has chiefly to guard against is, the escape of his prisoners, because that is a result which cannot be hidden, and will not escape animadversion. But the love of ease prompts him to take the easiest means for this purpose; locking up in dungeons, loading with irons, and prohibiting communication from without: in other words, all the measures which are the most tormenting to the prisoner. If the prisoner, confiding in his ingenuity or his strength, makes any attempts to free himself from this misery, by escaping, the disturbance which is thus given to the ease of the jailor, is a cause of pain, proportional to the love with which he cherishes his ease; this pain, excites resentment, resentment calls for vengeance, and the prisoner is cruelly punished. The demon despotism reigns in his most terrific form.

This is only one half of the evil. The servants of the jailor, the turnkeys, as they are called, and others who wait upon the prisoners, are as fond of their ease as the jailor is of his. If the jailor has not adequate motives to make him take care that the business of the prison is well done, he will repose the same confidence in his servants, which the magistrates so liberally exercise towards him. He will leave them to indulge their ease, as he could not do otherwise without disturbing his own.

From the servants of the prison indulging their ease, neglect of the prisoners is the immediate and unavoidable consequence. From neglect of prisoners, that is, of men placed in a situation destitute of all the means of helping themselves, all those evils, which, in another situation, could be produced only by the most direful oppression, immediately ensue.

Upon the servants of a gaol, cherishing their ease, and left by their superintendents to do so, every call of a prisoner for help, for relief from any annoyance, is felt as an injury, and resented as such. Cruelty speedily comes, as a co-operator with neglect, to fill up the measure of the prisoner's calamity.

The prisoner, finding himself destitute of all remedy, except he can prevail upon the people who approach him to remove some of the causes of the misery which he endures, has recourse to bribery, when he can possibly command the means; and then pillage, without limit and without mercy, is added to all the evils of this den of horrors.

If such are the consequences of entrusting the management of prisons to persons who have no interest, or not a sufficiency of interest, in good management, we have next to consider the important question, By what means a sufficiency of interest in good management can be created? We need not have any doubt, that if a sufficiency of good accrues to the managers from every particle of good management, and a sufficiency of evil from every particle of bad, we shall have as much as possible of the good, and as little as possible of the evil.

1. The grand object, as we have stated, of reformatory discipline is, to create habits of useful industry.

2. A second object is, to preserve the health of the prisoners, and impose upon them no suffering, not implied in the conditions of their confinement, or prescribed by the judge.

3. A third is, by moral and religious tuition, to generate and strengthen good dispositions.

4. A fourth is, to attain those ends at the smallest possible expense.

It is not difficult to give the manager or keeper of a reformatory prison or Penitentiary, a very strong interest in all these important results.

We have already seen, that the mode of giving to the prisoner a motive to labour, is, by giving him a share in the produce of his labour.

It is evident that an equally certain mode of giv-

ing to the jailor a motive for obtaining as much of that labour as possible, that is, for doing all that depends upon him to make the prisoners labour as much as possible, and as productively as possible, is by giving him also a share in the produce of their labour.

It may be said, however, that if the jailor receives a share of the labour of the prisoners, he will have a motive for making them labour too much: labour may be so excessive as to equal the severest torture.

Effectual expedients, however, for the prevention of this evil, are easy and obvious. In the first place, it does not seem necessary that the labour should be in any degree compulsory. If a prisoner is, according to the rule above laid down with respect to the cheapest fare, confined to the coarsest kind of bread, and water, if he does not labour, but has it in his power to add to his enjoyments by labouring, more especially if he may labour in company, but if he will not labour, must remain in solitude, the cases will be exceedingly few in which compulsion will be needful; and these might, if it were deemed of sufficient importance, be specially provided for by the legislature.

If a man may work, or not work, as he pleases, and much or little as he pleases, there is no need of any farther security against excessive labour. If there were, it would be afforded by the interest which it is easy to give to the jailor in the health of the prisoner.

Giving to the jailor a share in the produce of the labour of a prisoner has two happy effects; not only that of giving him an interest in rendering the value of that produce as great as possible, but that, also, of giving him an interest in the health of the prisoner, because the produce of a man's labour is greater when he is in health than when he is not.

This may be encreased by giving to the jailor, through a very obvious channel, an interest, and an interest to any amount, in the life of each prisoner. It being ascertained what is the proportion of persons of a similar age that die annually, when not confined in a prison, all that is necessary is, to entitle the jailor to a sum of money for each of the individuals above that proportion whom he preserves alive, and to make him forfeit a sum for each individual above that proportion who dies. This sum, it is evident, may be sufficiently high, to ensure, on the part of the jailor, a strong desire for the life, and thence a proper attention to the health of the prisoners.

Another particular in this case requires attention. It is obvious, that the motive of the prisoner to render the quantity or value of his labour the greatest, is, when the share which he enjoys of it is the greatest. It is equally obvious, that the motive of the jailor to promote the augmentation of this quantity or value is the greatest when his share is the greatest.

If the whole of the produce of the labour of each of the prisoners were left to be divided between himself and the jailor, the motives of the two parties, taken jointly, would be at the highest. And the question then would be, according to what proportion should the division be made?

The peculiar circumstances of this case permit the most decisive answer to be returned. No evil can accrue, and every good purpose is best gained, by allowing the jailor to take as much as he pleases. It being first established that he can employ no compulsory methods, that the prisoner must have as much of the coarsest fare and accommodation as he needs, whether he works or not, and that work can thus be obtained from him only by the operation of reward, it will be the interest of the jailor to make his reward sufficiently high to obtain from him all the work which he can perform, and, in his situation as a criminal, he ought, generally speaking, to receive no more. The propriety of this regulation, therefore, rests on conclusive evidence.

Here, however, an objection, worthy of attention, occurs. If the jailor receives so great a proportion of the produce of the labour of the prisoners, he may receive a much higher remuneration than the nature of his duties requires; and so far the public is deprived of a fund which ought to be available for the public service.

This observation is true; and the question is, in what manner can the separation of what is necessary in remuneration of the jailor, and what should be detached for the benefit of the public, be most advantageously made?

If the situation of the jailor affords more than an adequate reward, he will be willing to give something annually in order to retain that situation. And for measuring exactly what he ought to give, there is a sure and a well tried expedient: it is, to lay the thing open to competition.

By this expedient, a double advantage is gained: for both the public receives as great a share of the produce of the labour of the prison, as is compatible with the due remuneration of the jailor; and the jailor being entitled, in the first instance, to share the whole of the produce with the labourers, having both to pay what he owes to the government, and obtain his own remuneration out of his share, has a motive as strong as if the whole were his own, to render the produce as great as possible.

It will easily be seen that this contract between the public and the jailor, if sufficient securities can be taken for its being cancelled, as soon as misconduct on his part should render it desirable that it should be so, ought, for important reasons, to be concluded for a considerable number of years, or for his life. It is of importance that those individuals, who are to undergo the reformatory discipline, and who are unacquainted with any trade, should, especially if they are young, be taught the trade in which their labours can be turned to the greatest account: and, to make it the interest of the jailor to have them taught, it is evident that he must have the prospect of enjoying the benefit of their skilled labour for a sufficient length of time. This short illustration we hope will suggest to the reader sufficient reflections, for evidence on this point; and we must hasten to the remainder.

We have now shown, to how great an extent, upon the plan which we have thus briefly sketched, the interest of the jailor is rendered co-incident with the ends which are in view, and the most effectual

of all securities is obtained for the goodness of his management. We proceed to show what additional securities this plan enables us to provide.

Let us, first of all, attend to the power of inspection, which may be afforded in a degree altogether unparalleled. By the admirable properties of the building which we have recommended, not only is the conduct of the prisoners rendered wholly transparent to the jailor, but the conduct of the jailor may be rendered equally transparent to his inspectors. And as the central lodge, or tower of inspection, may be entered by any number, without giving the least disturbance to the prisoners, without their even knowing that any body is there, the public may be admitted on such terms, as to afford the full benefit of public inspection,—the most efficient of all inspections,—over the whole economy of the prison. By means of whispering tubes, oral communication might be permitted with the prisoners, at such times, and under such regulations, as would prevent it from interfering with the working hours, or other parts of the discipline, to all persons who might have a wish to hear if they had any complaints.

Another very simple expedient would make an important addition to the list of securities. It ought to be an obligation on the jailor to keep a book, in which all complaints of the prisoners should be entered, and, as often as they could write, signed with their names. Along with the complaint should be entered a statement of what had been done for removing the ground of the complaint, or of the reasons for doing nothing. And this book should be open to the perusal of the public, and should lie in a place convenient for the inspection of all the visitors of the prison.

A still more important and indispensable security would be, the obligation of the jailor to present, annually, to the principal court of justice, such as the Court of King's Bench in England, a report on the management and state of the prison during the preceding year, containing, with all other points of useful information, exact accounts of the receipts and disbursements; to verify these statements by his oath; to print and publish them at his own expense; and to answer, upon oath, all interrogatories, made to him, in open court, by the judge, or by any other person, how much soever the answer might tend to his own crimination; and this as often as the judge might call upon him for such a purpose. By this means, with the obvious security afforded for other still more important ends, so perfect a knowledge would be communicated of the gains of the jailor, and the mode of obtaining them, as would ensure an accurate bargain, rigidly proportioned to the amount of them, as often as the contract came to be renewed.

The last thing which we think it necessary to recommend in the shape of a security, would operate as a test of the efficacy of the management in its character of a reformatory discipline. The jailor should be held bound to pay a certain sum, varying in proportion to the length of time during which the prisoner had been subject to his discipline, for each of the prisoners who, after liberation, should be convicted of a crime.

Connected with the important part of the subject relating to the labour of the prisoners, it is proper to bring to view the advantage of a subsidiary establishment for receiving and employing those who might be liberated from the prison. It is a well known ground of lamentation, that persons liberated from a prison, find often great difficulty in obtaining employment, and are constrained, by a kind of necessity, to betake themselves to their former evil courses, though with the inclination to have devoted themselves to honest industry, had the means not been denied them. The best mode of obviating this great evil would be, to have a subsidiary establishment, the architectural form the same as that of the prison, in which the jailor should be obliged to receive all persons who have been liberated from the prison, and who make application for admittance; and to employ them on the same terms as the prisoners, with the single exception of its being in their power to remove when they please, and to make, in respect to terms, all such stipulations with the jailor as may be for their mutual advantage.

The next part of the subject to which we proceed, is the plan according to which the prison shall be supplied with the articles which the prisoners are enabled by their labour to purchase.

As there are certain articles, such as intoxicating liquors, which ought to be altogether withheld, unless for special reason permitted, and as the jailor could not have a sufficient command over the articles conveyed into the prison, unless he had, in his own hands, the power of supply; as the intercourse, also, which would be created with strangers, if the prisoners were at liberty to purchase of whom they pleased, would be incompatible with the discipline of the prison, the power of supplying articles of purchase to the prisoners ought to be confined to the jailor.

If it be objected that the jailor would thus have the power of oppressing the prisoners, by selling bad articles, or good articles too dear, the answer is, That he could not. We have already seen, that in order to derive from the prisoners the greatest quantity of profit to himself, he must give to them a reward for their labour sufficient to make them labour to the most profitable account. But if he sells articles to them at more than the usual price, this is merely a reduction of the reward left to them for their labour: this he cannot reduce beyond a certain point, without reducing the amount of his profit; and any greater reward than up to this point, the nature of the case renders undesirable.

We have now then stated all that seems necessary to be said on the three great subjects; 1*st*, Of the structure and form of the prison; 2*dly*, The securities which may be applied for obtaining good conduct on the part of the jailor; and 3*dly*, The first and principal part of reformatory discipline, namely, voluntary labour.

The remaining conditions of reformatory discipline will not require much explanation.

1. Separation, as far as concerns the sexes, and as

far as concerns the good from the bad, is now so generally attended to as an object of importance, that the danger sometimes is of other things being too much overlooked in the comparison.

In a prison, such as we have described, in which, by means of moveable partitions, the cells may be enlarged or contracted at pleasure, and in which the prisoners are all under continual inspection, the power of separation, to any desired extent, is complete.

The two sexes, though inmates of the same prison, and simultaneously subject to the same inspection, may be as completely disjoined as if they were inhabitants of a different region. By a piece of canvas, and nothing more costly, extended in the form of a curtain, from the boundary on each side of the female cells, in the direction of a radius across the central area to the inspection lodge, the females would be as completely cut off from seeing, or being seen by the male prisoners, as if they were separated by seas and mountains; the same effect would be obtained as to hearing, by merely leaving a cell vacant between those of the males and females; and thus the space appropriated to each of the two sexes might, in the easiest manner, be diminished or enlarged, as their relative numbers might require.

A much more complete and desirable separation, than that which is aimed at, as the utmost in other prisons, is easily attainable in this. The ordinary separation of young offenders from old, of the greatly corrupted from those who are presumed to be less deeply infected, is still apt to leave associations too promiscuous, and too numerous, not to be unfavourable to the progress of reformation.

The prisoners should be put together in companies of twos, and threes, and fours, seldom more; each company occupying a separate cell. It would be the interest of the jailor to put them together in such assortments as would be most conducive to the quantity and value of work they could perform, and to the goodness of their behaviour; that is, to the most perfect operation of the reformatory discipline: and his experience of their dispositions and faculties would of course fit him beyond any one else for making the selection.

It will have been all along understood, that, to attain the ends of inspection and economy, the same rooms or cells which form the day and working rooms on our plan, form also the sleeping rooms. Not the smallest inconvenience from confusion of things in the apartment can thence be derived; because the hammocks, which would be more convenient than beds, could be stowed away in little compass during the day.

It is also to be particularly observed, that whatever degree of seclusion might either be indulged to the feelings of an individual, or might be deemed conducive to his mental improvement, might still, upon this plan, be easily secured; because, by means of screens, a portion of the cell might be formed into as many private apartments as might be desired; and where experience of good conduct had laid a foundation for confidence, periods of seclusion, even from the eye of the inspector, might be allowed.

2. Nothing of great importance to be mentioned in this summary sketch seems now to remain, except schooling, and religious instruction.

The Sunday is the appropriate period for both. Sunday-schools are found by experience to be sufficient for communicating to children the important arts of reading, writing, and accounts. It would be obligatory on the jailor to afford the means of instruction in these respects to every prisoner who might not have attained them; together with all other means, not incompatible with the case, of promoting their moral and intellectual improvement.

3. The religious services proper to the day, and such other devotional exercises as might be thought requisite on other days, would be conducted by the chaplain, the prison affording remarkable facilities for bringing all the prisoners into a situation conveniently to hear; and also, which would be a circumstance of great importance, bringing the public from without, to participate in the religious services of the prison, for whom temporary accommodation in the vacant central area might be provided, and to whom, by the charms of eloquence and music, and the power of curiosity, it would be the interest of the jailor, by letting the seats, to provide sufficient attraction.

It seems to be necessary, before concluding, to obviate an objection, which, though it has seldom been urged as a reason against reformatory discipline, is yet considered as requiring a great deduction to be made in the estimate formed of its advantages. The objection is, that, by affording the means of employment to prisoners, we take away those means from a corresponding number of persons who are not prisoners, and thus sacrifice the deserving to the worthless.

This objection is drawn from some of the conclusions of Political Economy. That which affords the means of employment to labour is capital; in other words, the means of subsistence to the labourer, the tools he works with, and the raw material on which he is employed. When labourers are too numerous for the means of employment, it is evident that, if any new ones are added to the number, you can give employment to them only by taking it away from the old ones. It is, therefore, said, that by giving employment to prisoners, we make an equal number of honest workmen paupers.

In this objection, however, as is generally the case with false reasoning, a part only of the essential circumstances, not the whole, is taken into the account. In the first place, with regard to the prisoners, one principal part of the capital which puts labour in motion, namely subsistence, is afforded to them of course, whether they labour or not.

In the next place, the objection proves too much; for, if it would be better, for the sake of affording employment to others, that the man should do nothing in prison, it would equally be better that he should have done nothing out of prison; better that we should have a portion of our population useless than productive. According to this doctrine, the proper rule, whenever population exceeds the demand for labour, and wages are low, would be to give subsistence to a portion of the people, on the condition of their abstaining from labour.

Thus much of the allegation is true, namely, that when to the subsistence, which you would have given at any rate, you add tools and raw mate-

rials, you so far diminish the quantity of tools and raw materials which can be furnished to others. But, counting only this circumstance, another most important circumstance is left out of the computation. This deduction of tools and raw materials is made once for all. The productive labourer replaces the capital, which employs him, with a profit. Advance to him, for one year, the food and other articles which he needs, you never need to advance any thing more. What he produces in the course of the year, replaces the food and all other articles which he has used, with a profit. But if he has not laboured, he has produced nothing; you have to supply him, therefore, with the means of subsistence, not one year, but every year, from the produce of other men's labour. If he labours, you have to give him once, out of the general stock of means for the employment of labour, subsistence for a year, with tools and raw material, and you have no occasion to give him any more. If he is to be idle, you give him, it is true, only subsistence, without tools and raw material, the first year; but you have to give him subsistence, that is, so far to diminish the means of employing other men's labour, every year; whereas, if he is a productive labourer, for the advance which you make to him the first year, he not only exempts you from all farther deductions from the means of employing other men, but he every year adds to those means, by the whole amount of the profit made upon his labour. To make those persons, therefore, productive labourers, whom you must at any rate subsist, is to increase, not to diminish the means of employing others.

As to another objection which is sometimes offered, that the commodities produced in a prison glut the market, and injure other manufacturers, this is still more evidently founded upon the consideration of part of the determining circumstances, without consideration of the remainder. If it is meant to apply not to one class, or two classes of commodities, but to the mass of commodities in general, it may instantly be seen to be untrue. The men who become sellers of the articles produced in a prison, become buyers to the same amount. Whenever a man sells a greater amount of articles than before, he gets the means of buying an equally greater amount. He always brings as much of a new demand into the market as he brings of a new supply. If he introduces more of some one commodity than the market requires, and reduces the profits on producing it, capital leaves that employment till the inequality is redressed. If the number of people is the same, and the quantity of commodities is encreased, it is a contradiction in terms, not to say that the circumstances of such a people are improved.

Having answered these objections, it does not occur to us that there is any thing more which in this outline it is necessary for us to add. The plan, both of construction and management, appears to us simple, and easy to be understood; and to offer securities for the attainment of the end, such as the imperfection of the human powers, seldom permit to be realized. In the delineation presented, the only merit we have to claim is that (if our endeavour has been successful) of adding perspicuity to compactness. There is not, we believe, an idea which did not originate with Mr Bentham, whose work ought to be the manual of all those who are concerned in this material department of public administration. (F. F.)

PRUSSIA.

When the article under this head in the *Encyclopædia* was written, the kingdom of Prussia was reduced to a very low condition, and its boundaries contracted within a very narrow compass. Its capital and fortresses were in possession of the armies of France, and the whole country was considered merely as the highway to the future scenes of conquest which Buonaparte had planned. By a treaty of peace, which was merely nominal, since France fulfilled none of her part of the stipulations, the Prussian dominions were considerably curtailed, by the cession of many provinces to the powers that were allowed to exist, with an apparent sovereignty, under the control of the French chief. The reverse which the arms of France received in Russia led the Prussian monarch, who was, in reality, a prisoner in his capital, to break the chains by which he was bound, and turn the whole force of his state against his conqueror. During the lowest depression of his kingdom, though his army was reduced and his finances seized by his enemies, yet some part of the internal management of his affairs was left under the direction of his own ministers. As long as the French occupied his country, though the number of his troops in actual service were but few, yet, by dismissing those who had been sufficiently drilled, and enlisting a constant succession of new recruits, when the proper period for exertion arrived, so great a proportion of the inhabitants had been taught the use of arms, that, from the general spirit of indignation which existed against France, and the simplicity of the system of recruiting which had been long established, no difficulty was found in raising, almost instantly, an army of numerous and moderately instructed soldiers. The French had, indeed, stripped the kingdom of arms, but the deficiency was supplied, with unexampled promptitude, from the arsenals of Great Britain; so that, within a few months after the retreat of the French from Moscow, the Prussian monarch was enabled to bring into the field an army of more than two hundred thousand men. The principal fortresses were garrisoned by the enemy, but the communication between them was completely cut off, as soon as the French had been compelled to abandon the fields of Prussia, and collect their forces in Saxony for the campaign of 1813. During that year the arms of Prussia, united to those of Russia and Sweden, at

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first, and subsequently with those of Austria, were splendidly victorious, and crowned a brilliant campaign by the decisive battle of Leipsic; by which Prussia and the whole of Germany were at length freed from that Gallic yoke which had pressed them down for the seven preceding years. The Congress which assembled in Vienna, after the conquest of France, had the difficult and dangerous task of assigning to the various powers who had contributed to that event the dominions which, by right of conquest, had fallen among them; and after various discussions, and it is reported, after altercations that threatened the renewal of hostilities, settled the state of Europe according to the divisions that now exist; and made such provision for extending the power of Prussia as was thought most conducive to the security of the balance of power on the continent.

Prussia has been gradually rising in importance in the scale of European politics, and has increased its dominions in the last hundred and thirty years by conquest and cessions, as well as by the augmentation of its territorial wealth and its population. On the death of Prince Frederick William in 1688, the number of Prussian subjects was 1,500,000; at the death of King Frederick in 1713, they were 1,620,000; at the death of Frederick William the First in 1740, they were 2,200,000; at the death of Frederick the Second in 1786, they were 5,800,000; at the death of Frederick William the Second in 1797, when the present king ascended the throne, they amounted to 8,700,000, and by the late acquisitions they have reached to 10,536,000. The divisions which Prussia received in 1815 were, from France, the province of the Lower Rhine, and part of Juliers Cleeve and Berg; from the kingdom of Westphalia (created for Jerome Buonaparte), the principality of Munster and part of Berg and Cleeve; from the kingdom of Saxony, the ancient duchy of that name, and a part of Lausatia; and from Poland, the province of Posen, which had, indeed, been formerly added to this kingdom on the last division of that country.

Boundaries.

Prussia has no intercourse betwixt its eastern and western provinces, without passing through the dominions of other princes. Hanover, to the north, is interposed between the eastern and western provinces of Prussia; and in the southward parts of it, the sovereigns of Brunswick, Waldeck, Hesse-Casel, Hesse Darmstadt, Nassau, Saxe Weimar, and Saxe Gotha, intercept the direct communication. The boundaries of this kingdom are on the north, the Baltic Sea, and a small portion of the duchy of Mecklenburg; on the east, Russia and its dependant kingdom Poland; on the south-east Austria; on the south the kingdom of Saxony, and the Saxon duchies; on the south-west Bavaria and part of France; and on the west France and the kingdom of the Netherlands. In describing these boundaries, it is, however, necessary to remark, that some parts of the kingdom are small detached portions entirely insulated by the dominions of other powers, such as Neufchatel in Switzerland, Suhl in Saxony, and Rahnis in Saxe Weimar.

Divisions.

The great divison of Prussia is into those provinces which are in Germany, which form a part of the Germanic Confederation, and maintain a stipulated number of troops for its defence; and of those states which have no connection with that alliance.

	Extent in British Statute Acres.	Number of Inhabitants.	Capitals.
The German Provinces are,			
Brandenburg	11,025,280	1,297,795	Berlin.
Pomerania	8,331,520	700,766	Stettin.
Silesia	10,598,400	1,992,598	Breslaw.
Saxony	6,663,040	1,214,219	Magdeburg.
Westphalia	5,534,720	1,074,079	Münster.
Juliers Cleves and Berg	2,325,760	935,040	Cleves.
The Lower Rhine	4,039,360	972,724	Coblentz.
Prussian Provinces out of Germany.			
East Prussia	10,333,440	919,580	Königsberg.
West Prussia	6,844,800	581,970	Dantzic.
Posen	7,919,360	847,800	Posen.
	73,615,680	10,536,571	

Population.

Of this population, by the census of 1817, the males were 5,244,308, and the females 5,320,535. The marriages were 112,034, the deaths 306,484, and the births 454,031; of which 53,576 were illegitimate; the proportion of sexes born was 20 males to 19 females. The deaths, two in 69, were one male to 33, and one female to 36. Of the illegitimate children that were born, three out of every ten died in the first year, of the legitimate only two out of every ten.

The inhabitants of this kingdom are distributed in the following manner:

In 26 cities of more than 10,000 souls	836,079
136 cities of more than 3500 and less than 10,000 souls	765,936
194 towns between 2000 and 3500 souls	508,933
407 towns between 1000 and 2000 souls	597,947
258 towns of less than 1000 souls	186,937
	2,895,832
In villages and scattered houses	7,640,739
	10,536,571

Prussia.

Different Races and Languages.

The people of this monarchy are of different races. The most numerous body are of German origin, divided by language and customs into the High and Low Germans. These together amount to 8,600,000, and, with the exception of the province of Posen, form everywhere the great majority. The Low German or *platt Deutsche* language is generally spoken in the countries between the Rhine and the Elbe, on the north side of the Hartz mountains, and prevails along the Baltic, through part of Brandenburg and Pomerania. In Silesia, in the southern part of Saxony, in the trans-Rhemish provinces, and in East Prussia, a dialect, or rather differing idioms of the High German tongue, are spoken; but all far removed from the pure language of Saxony, or, as it is called, *Der Meissnichen Dialect*. The Walloons in the vicinity of the forest of Ardennes, and the colonists descended from French refugees at the time of the revocation of the edict of Nantes, are now much mixed with the German inhabitants, but many of them have confused the two languages, and speak a kind of German-French-Patois. Among the higher classes in every part of the kingdom the pure High German language is spoken, generally with the peculiar idiom and pronunciation of Berlin; and that language is universally used in books, in the churches, in the courts of law, and in the more important transactions of commerce.

The Prussian subjects of Sclavonian origin amount to about 1,750,000, and retain their original language. About 1,500,000 of these are usually denominated Poles, and are the inhabitants of parts of Posen, West Prussia, and Silesia. About 50,000 people in Lithuania have a peculiar language of their own. The *Wenden* or Vandals have also a different language from all the other subjects of Prussia. The whole number of them is about 225,000. They are settled, a few in the province of Brandenburg, the remainder in the province of Pomerania, and the districts of Leignitz and Kassubon in East Prussia. To these must be added the Jews, amounting to about 130,000 individuals, who are to be met with in every part of the Prussian territory, but principally in the province of Posen.

Religion.

The predominant religion in Prussia is the Protestant, now denominated the Evangelical Confession; comprehending Lutherans, Calvinists, Hernhuthers, or Moravians, and Hussites, The professors of it amounted in 1817 to 6,370,380 individuals; of whom more than 6,000,000 were, before the union, of the sects of the Lutheran persuasion. They form a large majority in the circles of Konigsberg, Gumbinnen, Dantzic, Berlin, Potsdam, Frankfort, Stettin, Koslin, Stralsund, Breslaw, Reichenbach, Leignitz, Magdeburg, Merseburg, Erfurt, and Minden. The Catholics amounted at the same period to 4,023,513; and formed the majority in the districts of Marienwarder, Bromberg, Posen, Oppeln, Munster, Arensberg, Cologne, Dusseldorf, Cleves, Koblentz, Aachen, and Treves. The Mennonites, a species of Anabaptists, amount to about 15,000, and the Jews, as before stated, to about 130,000. These different parties are all equal in the eye of the law, have the same protection for their worship, and are all alike eligible to every civil, judicial, and military office.

Prussia.

Ranks of Society.

The inhabitants are divided into classes. At the head of these the nobles are of two kinds practically, though not legally. The high nobility are the princes who were formerly petty Sovereigns on their own estates, but whose independence has merged in the general government; they amount to about fifty families. The lower nobility, consisting of about 200,000 individuals, have preferable claims to certain offices in the army, the state, and the church; but their privileges have been gradually contracting, and they are now in almost every point only equal to the burghers or citizens. The burgher class of inhabitants, including the military, amount to 2,900,000 individuals. The power of the guilds in the cities has been gradually diminished, and they are now scarcely obstacles, as they were formerly; here, and still are in other parts of Germany, to the exercise of industry and ingenuity in any profession which individuals may select for themselves. The inhabitants who enjoy personal rank are the civil officers of government, and the clergy; the former with their wives and children comprehend 170,000, and the latter about 50,000 individuals. The whole of the other people are the *Bauers* or peasants. They were formerly slaves, and were usually sold, as in Russia, with the estates to which they were attached; but their lot has been progressively ameliorated, and during the reign of the present king, the last vestiges of this barbarism have been totally abolished. The final extinction of personal slavery was not decreed till September 1811; and from the military events which speedily succeeded, it has not been practically destroyed till within the last four years. At present the peasantry, who amount to two-thirds of the whole population, are a species of copyholders with customary quitrents and herriots to the land owners; but they may purchase land, and become themselves proprietors; a benefit only recently conferred on them, and which those who are industrious and economical very eagerly avail themselves of.

Soil and Agricultural Productions.

As the cultivation of the soil is the employment of three-fourths of the inhabitants of the dominions of Prussia, it deserves the first notice in a description of the country. The greater part of the territory is a sandy soil, generally very level, and often covered with heaths. The woods of it are nearly one-fourth of the whole surface, and only certain portions near the rivers, or in particular situations, can be considered as fertile, or even grateful soils. The wants and the industry of the inhabitants, aided by a rigid parsimony, directed and stimulated by a paternal, though absolute government, have changed, in the course of the last century, the most sterile and unproductive kingdom of Europe into a territory which more than supplies the demands of its own inhabitants, and leaves a surplus quantity of corn in most years for provisioning other countries, Besides its corn, it exports to the neighbouring states vast quantities of fruits, whose cultivation was unknown in the kingdom, at the accession of Frederick the Great in 1740. In so extensive a territory there will necessarily be great inequalities in soil, in cul-

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ture, and in productions. Many barren sandy plains are to be found, which are deemed to be more expensive to bring into cultivation than could be repaid by their productions. This is especially the case in the Churmark, in Lower Lausatia, and in some of the Westphalian provinces, where large spaces are occupied by heaths; such as the heaths of Minden, which extend over 10,000 acres, those of Lippstadt of 20,000, and the still larger ones of Senner and Fuhling. In East Prussia are several very extensive morasses, which require draining to render them productive. In the fruitful district of Magdeburg the bog of the Dromling covers more than 100,000 acres. A part of it, indeed, is in the Hanoverian, and a part of it in the Brunswick territory, which prevents the necessary drains from being executed, which would make it one of the most valuable tracts of land in that part of Germany.

The most fruitful corn land in the kingdom of Prussia is the vicinity of Tilsit, and some other districts of East Prussia, and the greater part of the province of Posen. In West Prussia the district of the Netz, the country round Marienburg, and that near Dantzic and Elbing, are excellent corn countries. In the Mark of Brandenburg only some districts, such as the Mark of Prignitz and the Uker-mark, are celebrated for the quantity and quality of their grain. In both Prussian and Swedish Pomerania, and especially on the island of Rugen, excellent corn is raised, as well as in some small portions of New Silesia. The soil is very favourable for all kinds of grains in the duchies of Saxony and Magdeburg, and in Thuringia, and in the principalities of Halberstadt and Quedlingburg. These divisions in favourable seasons may be considered as the real granaries from which the less fertile parts of Prussia draw their supplies of corn.

The western part of the Prussian dominions are far less productive in grain than the eastern. A few only of the Westphalian provinces are highly fruitful. The districts most eminent for corn are the vicinity of Minden and of Padderborn, the borders of the Soester, and circles of the Sieg and the Wupper. In the Rhenish provinces the neighbourhood of Julich, Bonn, Cologne, Coblentz, Kreusnach, Bacharach, and the banks of the Meuse, are tolerably fertile. Though some parts of the kingdom are deficient, yet, on the whole, Prussia grows more corn than its consumption requires; and in favourable years the value of the surplus exported to other countries has amounted to from 1,800,000 to 2,000,000 florins, each florin estimated at two shillings Sterling. The principal grains of Prussia are wheat, rye, barley, and oats. The quantity of rye far exceeds that of every other kind of corn; it forms the principal aliment of the inhabitants, among whom wheat is seldom eaten in bread. Pease, both white and grey, are extensively raised, and especially that description of them known in England by the name of "Prussian blues." Beans of all varieties are cultivated in the soils on the borders of the rivers, that are suitable to their growth. Buck wheat is much sown in some parts, and forms an important part of the sustenance of the labouring classes. An article for food is collected in Prussia, especially in Brandenburg, from the seeds of the grass called *Festuca fluitans*. It is manufactured into a substance called *Manna grits*, and is more agreeable to the taste, though employed for the same purposes, as oatmeal with us. The cultivation of potatoes has for many years past been gradually extending, and is become so great as to supply almost the sole aliment of a very great proportion of the labouring population.

Cattle.

The most productive branch of rural economy, next to corn, is that of breeding and fattening cattle. The practices in this branch are, however, of a very low description; and though the different races, especially of cows, are to be found in Prussia, yet so little attention has been paid by crossing them, to obtain the most perfect animals, that they are almost all very indifferent. The sheep generally are bad; but of late years great improvements have been made in their fleeces by the introduction of the Merino and Paduan rams. The fine woolled sheep now amount to 7,000,000, and supply the manufacturers with that raw material which used formerly to be furnished principally from Spain. The races of horses are not good, though great efforts have been made by the government to improve them, and establishments of stallions, for gratuitous propagation, are fixed in several parts of the kingdom. The breeding of swine is a very considerable employment; and the hams, bacon, and sausages made from them form a large proportion of the animal food of the inhabitants of the Prussian dominions.

Appropriation of the Soil.

The great deficiency in the rural economy of Prussia, as in most parts of the Continent, is the small portion of land appropriated to pasture. Hence the number of cattle maintained is small in proportion to its extent; and the effects of the deficiency of manure is to be found in the small increase on the different crops of grain. The average increase is stated to be six for one of wheat, five and three quarters for one of barley, four for one of rye, and four and a half for one of oats. The land of this kingdom is thus appropriated:

	English Acres.
Under the plough	29,224,741
In garden culture	295,302
Vineyards	36,908
Meadows and pasture	14,672,000
Woods, forests, and plantations	17,574,294
	61,803,245

The remaining 11,800,000 acres are either in lakes, ponds, rivers, canals, roads, the sites of cities, towns and villages, or of so bad a soil as not to be deemed worth cultivation.

Productions furnished to Commerce from the Land.

Besides articles for food, the soil of Prussia produces many for commerce: the principal of these is flax, which is grown in every village, and almost by every peasant. Besides what is used by the growers for their own domestic manufactures, the quantity annually brought to the markets is calculated at 22,000,000 pounds. Two-thirds of this quantity is produced from Silesia alone. It is gene-

rally of a good quality, with a fine and long fibre, especially when raised from foreign seed. This change of seed is found so essential, that large quantities are annually brought from Russia; and the seed preserved at home is mostly used for making oil and oil cake, with the latter of which the oxen are fattened. Tobacco, madder, woad, saflour, and hops, have been much grown, especially during the continental restrictions of Buonaparte; and though the openings of foreign commerce have much discouraged their cultivation, they are still continued upon a small scale. Chicorium, or succory, as in other parts of Germany, is much used as a substitute for coffee; and though the peace has reduced the price of the latter article, the succory finds an extensive sale, and is still cultivated very largely in many districts. The wine made in Prussia before the acquisition of the Rhenish provinces was of a bad quality, and scarcely superior to vinegar; but these territories yield wine of good flavours and great strength: the annual quantity is calculated to vary from six to eight million gallons. The forests, amounting, as before stated, to nearly two-sevenths of the whole country, furnish timber for building and for exportation, fuel, tar, pitch, rosin, and potash, and are more valuable from the great facilities which the rivers and canals afford to internal navigation, by which their products can be easily conveyed to the borders of the sea.

Mines. The mines are by no means worked to the extent of which they are capable. Every province possesses iron, which is prepared in forges and blast-furnaces in their vicinity. They are principally worked with charcoal from the neighbouring forests, but in some few instances with fossil coal. Little or no iron is exported, as it can be made cheaper in countries that have more easy access to the ocean. The mines of rock salt, and the salt springs, are sufficiently worked to supply the consumption of their vicinity, but the provinces in the Baltic Sea find it more advantageous to draw their supplies from the mines of Cheshire. Coals are found in Silesia, Saxony, and Westphalia; but the mines are not extensively worked: the whole quantity raised not exceeding 330,000 chaldrons. From the unproductive state of the gold mines of Silesia, they ceased to be worked in 1798. The silver mines are those of Tarnouitz and Rudelstad, in Silesia, and of Mansfeld and Rothenburg, in Saxony. Their united produce does not at present exceed 160,000 ounces. The other minerals are copper, lead, cobalt, calamine, arsenic, alum, vitriol, and saltpetre; but they do not yield sufficient for the internal consumption. Amber is almost an exclusive production of Prussia. It is found in mines, as well as procured by the fishermen on the shores of the Baltic. It belongs to the crown, and is let to farm.

The capital, and annual produce of the land of Prussia has been calculated, by Professor Krug, from documents in the *Statistical Bureau*, at Berlin, as follows:

	Value of the Capital in Pounds Sterling.	Annual Income.
Ploughed land,...... L.	200,513,150	8,029,500
Pasture & grazing land,	77,890,150	2,614,566
Woodland,...	75,729,150	1,029,166
Gardens and vineyards,	11,591,650	440,483
Mines, ...	1,195,850	47,500
Fisheries on lakes & rivers,............	2,964,775	118,592
Game (abundant in the markets),......	2,642,290	105,291
	372,527,015	12,376,128
To these may be added the annual produce of the live stock, after deducting the amount of the supposed produce of the pasture land, ...		10,754,098
	L.	23,130,226

According to the estimate of the same statistical writer, the live stock in the whole of the Prussian dominions, and their annual produce, was—

Species of Stock.	Numbers.	Produce.
Horses and foals,......	1,661,800	0,355,000
Oxen, ...	1,255,000	
Cows,....................	2,355,900	10,140,010
Heifers and calves, ...	1,646,918	
Sheep and lambs, ...	11,230,000	1,663,450
Swine,.....................	2,644,000	622,400
Goats, ...	181,000	7,441
Hives of bees,...........	521,000	356,090
Feathered tribes,.........		266,475
		13,410,866
From which is to be deducted the supposed annual proceeds of the meadow and pasture land,.....................		2,614,566
Leaving the net produce of the stock,	L.	10,796,300

Manufactures. Prussia is a manufacturing country, though these branches of industry give employment to a far less portion of its inhabitants than the cultivation of the soil. The most natural manufacture is that of linen cloth, the raw material of which, and all the parts which contribute to its perfecting, are produced at home. It has been long established, and extensively spread. In Silesia, especially, the habit of spinning fine thread has given to the females a delicacy of tact, that is only excelled in some parts of the Netherlands. Besides, the common articles for personal and domestic use, the finest and most beautiful damask services for the table are made, which are generally preferred to all others, in the higher circles, through the whole of Europe. Before the late

war, the produce of the linen of Silesia, from 34,910 looms, amounted to L. 1,689,915 Sterling; of which L. 970,000 was destined for foreign consumption. In the western provinces, the linen cloth is principally made for home consumption. The number of looms in the whole kingdom, in 1816, was 207,870.

The increase of Merino sheep has given a great stimulus to the fine woollen manufactures, especially to those in the newly acquired provinces on the French frontiers, where some of the best superfine cloths that Europe can exhibit are made. In the late department of the Roer, or, as it is now denominated, the circle of Aachen, in the towns of Eupen, Aachen, Montjoie, Stolberg, and Montmedy, fine cloths and cassimeres are manufactured, which are estimated to amount to L. 1,500,000 Sterling, and afford employment to upwards of 50,000 workmen, as well as to every kind of machinery that has been invented in England, or in any other country. The cloths for the dress of the middle and lower classes are wholly made within the kingdom from their native wools.

Cotton goods have been made to a considerable extent. In some instances the yarn is spun in foreign countries, and the weaving, bleaching, and dyeing only, executed in Prussia; and as the raw material, a foreign article, cannot be rendered so cheap as in England, this branch of industry has much diminished since the general peace. The iron manufactures are more than sufficient for the domestic consumption, and furnish to the value of about L.300,000 Sterling for exportation. There are three hundred paper-mills, which furnish the common kinds of paper in quantities sufficient for the consumption of the country; but the finer sorts are supplied either from England or France. Silk goods, and goods mixed either of silk and cotton, or silk and woollen, are chiefly made in the capital, in which, and in some other places, they give employment to about 20,000 looms. The various kinds of leather are made from skins produced at home, as far as they are found sufficient, and the deficiency is supplied from Buenos Ayres, through the intervention of England or Spain. Copper and brass wares, for all domestic purposes are made, partly from the copper and calamine of their own mines, but chiefly with copper furnished by other countries. The amount of these wares is estimated at about L. 200,000 Sterling. Tobacco, snuff, sugar, soap, candles, cabinet-ware, earthen-ware, porcelain, tin goods, and almost every article of common consumption, is made within the kingdom. As no wine is made in the eastern part of Prussia, the common beverage is either beer or brandy distilled from the native grains: the establishments for brewing and distilling are consequently very numerous, but none of them approach in magnitude to the larger concerns of a similar kind in England. The whole quantity of beer brewed is 4,243,100 casks, of 50 gallons each. The consumption of corn brandy is upwards of 8,000,000 gallons. In the larger cities, the letter-founders, printers, engravers, musical, optical, and mathematical instrument makers, gold and silver smiths, jewellers, watch-makers, and other similar artificers, are to be found as abundant and as skilful as in the other countries on the Continent. The number of workmen, including masters, journeymen, and apprentices, exclusive of females and children, is estimated at 350,000, and the value of their productions, above the cost of the raw materials, is calculated to amount to L. 7.600,000 Sterling.

Rivers.

Few of the countries of Europe have been more favoured by nature than Prussia, with streams that contribute to fertility and intercourse; and the labour of the inhabitants has been advantageously directed to several public works, which have facilitated the communication between the different rivers. As the slope of the whole Prussian dominions is towards the west and north, all the rivers that rise in, or pass through them, empty themselves either into the Baltic Sea or the German Ocean. The streams that merge in the first of these are the Niemen, which comes out of Russia, and becomes navigable at Schmaleninken: about ten miles below Tilsit it divides into two branches, which, through the Kurish Haff, empty themselves into the sea. During its short course through the Prussian territory, it receives, on its right side, the waters of the Schesschappe, and on its left those of the navigable river Jura. The Pregel is composed of the united streams of the Pisa, Ranit, Russe, Augerap, and Inster: after it assumes its name it receives the Deine near Tapiau, and the Alle near Wehlaw; it becomes navigable near Gatterburg, and, passing Königsberg, discharges its streams by the Frish Haff into the Baltic. The Vistula, or, as it is better known on the Continent by the name of the Weisel or Weichsel, rises in the Austrian part of Silesia. It passes through Poland, where, at Cracow, it becomes navigable. On its entrance into the Prussian territories, it divides into two branches, the eastern of which takes the name of the Nogat, and joins the Baltic near Elbing; the western is again subdivided into two arms, one of which is lost in the Frishe Haff, and the other reaches the sea near Dantzic. Its course, after entering Prussia, is about 140 miles, and during its progress, it is augmented by the streams of the Ossa, the Brahe, and the Mottlaw The Oder, rising in Moravia, enters the Prussian province of Silesia, soon after which, near Ratibor, it becomes navigable, and, after passing through Brandenburg and Pomerania, divides into two branches, and enters the great estuaries that communicate with the Baltic Sea, through the three mouths of Swine, Peene, and Divenow. Its course, in the Prussian states, is 370 miles, the general rate of its current is languid, and it is prevented from overflowing by embankments It receives, near Oderberg, the waters of the Oppa, near Breslau, those of the Ohlau, near Grosglogau, those of the Bartsch, near Neuzelle, those of the Neisse, and at Custrin, those of the Wartha. This last is the most valuable of all the secondary rivers of Prussia, because it affords the means of communication between the Oder and the Vistula. The rivers of Prussia which empty themselves into the German Ocean are the Elbe, coming from Bohemia. It is navigable at Muhlberg, where it enters this kingdom. It receives the Elster, near Wittenburg, the Muldau, near Dessau, the Saale, near Saalhorn, and the Havel, near Werben, soon

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after which, in its passage to the ocean, it quits the Prussian dominions. The Weser enters but a small portion of the territory of this kingdom, though it forms the boundary on the eastern side of the Westphalian provinces, from Holtzminden to Carlshafen. The only part where both its banks are in Prussia, is near Minden, where it has forced its way through the range of mountains, and formed the celebrated passage, well known to the ancients as the Porta Westphalica. The Rhine enters the newly acquired provinces of Prussia, at Bingen, a little below Mentz, and quits them at Kerkerdom, above Nimeguen. It receives, within the Prussian territories, the streams of the Nahe, the Lahn, the Moselle, the Ahr, the Erft, the Roer, and the Lippe. The Ems, though it rises in the province of Westphalia, is a small stream, not navigable till it enters the kingdom of Hanover.

Canals.

Most of the rivers of Prussia are so advantageously connected with each other, by means of navigable canals, that an uninterrupted intercourse is maintained by them from Halle and Magdeburg to Elbing; and the surrounding districts have the benefit of those facilities for exchanging their various productions. The Fredricksgraben canal, in East Prussia, is formed to avoid the dangerous navigation of the Kurishe Haff, in the intercourse between Tilsit and Memel. The Bromberg canal joins the Netze and the Brahe, and by their means the Oder and the Vistula. It is the most expensive of all the Prussian canals, having, within eighteen miles, ten locks. The commerce on it furnishes freight to about 600 barges annually, each of 30 tons burden, besides smaller boats. The Finnow canal unites the Oder and the Havel, is about twenty miles long, and has on it about 4000 small, and from 1600 to 1700 large boats. The new Oder canal shortens the navigation of that river, and serves also for the purpose of draining the meadows through which it passes. The Plauen canal connects the Havel with the Elbe, and is the channel of intercourse betwixt Berlin and Hamburg. The Fredrick Williams canal unites the Oder and the Spree. Besides these are others of less importance, viz. the Storkow, the Werbellin, the Klodnitz, the Saxon, and the Munster canals, all of which are of local benefit; and the Rhine canal, begun in 1809, but not yet completed.

Lakes.

The lakes of Prussia, especially on the eastern portions of the kingdom, are numerous and extensive. On the coast of the Baltic, those lakes, usually denominated Haffs, to distinguish them from the bays, are of fresh water. The largest of them, the Kurische Haff, on the north-east part, extends over 700 square miles. The Frische Haff, near Pillau, is of 360 square miles. The Stettin Haff is of nearly the same extent. Besides the lakes on the shore, those in the interior of the country are stated to exceed 1000, many of them from ten to twenty miles in length. In East Prussia are 300, in West Prussia 160, and in the province of Brandenburg 680. Many parts of these lakes have been contracted by embankments, and the soil they covered gradually appropriated to agricultural purposes. At present they supply vast quantities of fish, the right to take which is in many instances farmed at very high rates.

Climate.

The climate may be generally described as temperate and healthy, though, from the great variety of situations, there are many exceptions. On the borders of the Baltic, the winters are severely cold, and the weather changeable, raw, and foggy. The greatest degree of cold, in the last century, was from the 21st to the 25th January 1795, when Reaumur's thermometer was at 24° below zero. The greatest heat of that century was in the following summer, when the same thermometer was at 36° above zero. The middle provinces of Posen, Brandenburg, Silesia, Saxony, and the whole western parts of the monarchy, possess a more mild and less variable climate, but very different in the several localities. The heat on the sandy plains of Brandenburg is, in summer, very oppressive, and the air, from the abundance of stagnant water, frequently unhealthy; whilst in the vicinity of the Hartz, the cool mountain breezes are enjoyed. The banks of the Rhine and Moselle are covered with verdure before the inhabitants of Riesengebirgs and of the Lithuanian heaths have laid aside the fur pelisses of the winter. Upper Silesia, and the mountainous parts, have a much rawer climate and a longer winter than Lower Silesia; but though the air is milder in the latter, from the great quantity of its water, it is not more healthy.

Foreign Commerce.

The commerce of Prussia with foreign nations is much less than the extent of the country and the number of its inhabitants would lead us to expect. It is loaded with many restrictions, which, however necessary they may be deemed in a fiscal view, are vexatious and harassing. The commerce by land, by internal navigation, is principally with Austria and Russia, and with both those states the balance is unfavourable to Prussia. From Russia she draws hemp, corn, hides, tallow, and some other productions of the soil, and sends in return both linen and woollen cloths. From Austria she receives salt and wine, and has only linen yarn to send to that country. The provinces on the Rhine carry on very considerable traffic in wine and manufactured goods with the adjoining provinces in the kingdom of the Netherlands, and with several of the states of Germany.

As Prussia possesses no sea-ports, except on the Baltic, and as none of its harbours are calculated to receive ships of a great draft of water, or enjoy good entrances, there is very little commerce carried on beyond the limits of Europe. The shipping belonging to the different ports of Prussia, in 1817, consisted of 883 vessels, capable together of carrying 90,290 lasts of corn, or about 950,000 quarters. The greater part of their exports are conveyed by foreign ships, of which the British exceed in number those of all other nations together. Dantzic, once a Hans town, and the seat of extensive commerce, has much declined since it has become subject to Prussia, notwithstanding its favourable situation for exporting the productions raised on the banks of the Vistula and its tributary streams. It still, however, exports corn, wood, pot-ashes, linen,

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wool, wax, honey, horse-hair, and feathers; and imports colonial wares and some few manufactured goods. Königsberg exports corn, but the vessels to be loaded with it can approach no nearer than to Pillau. Elbing has lately increased by dividing the commerce with Dantzic, and the articles imported and exported are of the same description as constitute the trade of that city. Memel is, at present, the largest exporting city, and the corn, ship-timber and masts, pot and pearl-ashes, with flax-seed, are its chief commodities. Stettin has the greatest portion of the import trade, as, from its position on the Oder, it is best calculated to receive colonial produce, and forward it to the capital and to the centre of the kingdom. It is also the port in which the greater part of the vessels for the fisheries are equipped. Stralsund, though it enjoys a good harbour, has but little trade, from being destitute of water communication with the interior of the kingdom. The other ports of Prussia, Colberg, Rugenwalde, Stolpe, Barth, Swinemunde, and Wolgast, carry on some trade, and though not to a great extent, it is valuable, from being almost exclusively conducted in national vessels. The whole exports of Prussia, both by land and by sea, amount to about L. 4,500,000 Sterling; the whole of the imports to about L. 3,750,000; but in the latter is not included the products of their own oil and herring fisheries.

Government.

The government of Prussia is an unlimited Monarchy; for though in some of the provinces, by ancient custom, the States still exist, they seldom assemble, and only for such inferior purposes as regulating the debts or expences of their respective provinces. They have no legislative powers, and scarcely even the right to make representations to the monarch. The crown is hereditary in the oldest member of the royal family, whether male or female. The sole executive and legislative power is vested in the king, and his authority is less restrained by the ancient privileges and usages of his subjects, than that of any other European monarch. The administration is vested in a council of state, consisting of members of the royal family, and of the ministers of foreign affairs, of the finances, of justice, of public instruction, of trade, of the public debt, of police, and of war. The State Chancellor is president of this council, and to him all the heads of the different departments are accountable, and make their weekly reports. He is uncontrollable by his colleagues, and directed solely by the king. In the details of the administration, through all the inferior departments, there is much simplicity, and a degree of economy in remunerating public services, which scarcely finds a parallel under any other government.

Revenues.

The revenues of Prussia are derived from taxes on the land, on persons, on patents and licences, which are denominated direct contributions; and from an excise, or rather a custom duty, on foreign productions. A small sum is derived from stamped paper. In those provinces which were taken from the French empire, the taxes on land, on trades, on doors, and windows, as then established, are still continued, and will remain till the whole of these provinces are brought under the simple regulations established in the other dominions. More than one-fourth of the revenue of the monarchy is derived from the royal domains, and the hereditary rights or royalties, which are exercised over the mines, the salt springs, the game, the coinage, the posting and the postage, with some other branches. Though the higher branches of the administration appear to be benefited, by parsimony in the salaries, yet in the inferior department it appears to be injurious; as the petty officers, who are very numerous, are too poor to refuse bribes, and they are not deterred from the apprehension of dismissal from office, whose fair emoluments scarcely equal the wages of a day-labourer. As the revenue is returned to Berlin in a mass, from the different provinces, we give them in that form, rather than in the more detailed one of the several branches from which it is derived.

East Prussia	8,100,000
West Prussia.........	3,750,000
Posen	3,100,000
Brandenburg	9,000,000
Pomerania......... .	3,000,000
Silesia	13,500,000
Westphalia	8,413,000
Saxony	10,417,000
Juliers-Cleves-Berg	8,670,000
Lower Rhine	7,000,000
	74,968,000 Gulden.
	L. 7,520,000 Sterling.

National Debts.

Before the reign of the father of the present king, Prussia had no public debt, but usually a sufficient accummulation of money to meet any emergency that might occur. The present king, on his accession, by economy and regularity, had reduced the debt which his predecessor had incurred, when the rupture with Buonaparte in 1806 drew forth all his resources, and, till the year 1815, the debt continued to increase. Since the restoration of general peace, due measures have been taken for the reduction of it. The floating debt has been reduced to less than L. 2,000,000 Sterling, and the funded debt amounts to about L. 24,000,000 Sterling; in which is included a loan of L. 6,000,000 from British subjects, and the debts assumed on the cessions of territory from Sweden, Denmark, and Saxony, amounting to L. 650,000 Sterling. Besides this national debt, many of the corporate bodies have borrowed considerable sums, which were presented to the government in the most critical periods, and which are in progress of being liquidated from their own incomes.

Expenditure.

The expenditure of the government is upon a very low scale: no court can be less expensive than that of Berlin, and no monarch can be less attentive to his personal gratifications than the present king, who, like his predecessor Frederick II. appropriates but a small portion of his patrimonial income to his private purposes, devoting it principally to the ser-

vice of the state. The expenditure, in 1819, was,

Establishment of the royal household	L. 2,250,000
Military expenditure	37,500,000
Civil expenditure	7,500,000
Interest on the public debt	15,000,000
	62,250,000 Gulden.
	L. 6,510,000 Sterling.

Army.

The army of Prussia consists of regulars, and two kinds of militia, called the Landwehr and the Landsturm; the regulars are,

Guards	18,220 men.
Infantry of the line	112,140
Cavalry	19,232
Artillery and Engineers	15,408
	165,000

The regular ranks are filled by a conscription, which compels every young man, as he arrives at 20 years of age, to serve for a limited period. If the conscript can purchase his arms and accoutrements, and pay a small sum, he may, at the end of one year, pass into the landwehr, which is composed of this class of men, and of all others between 25 and 40 years. In time of peace, the landwehr is exercised but one day in the year, but in war it becomes a disposable force, and is marched wherever its services may be deemed necessary. It amounts to 160,000 men, including cavalry, infantry, and artillery. The other militia force, the landsturm, is composed of all males capable of bearing arms above 40 years of age. This force is only called out in periods of great emergency, and then its duty is entirely domestic, being confined to guarding prisoners and maintaining internal tranquillity.

Administration of Law and Police.

Prussia enjoys a peculiar Code of Laws, founded by Frederick the Great, upon the ancient customs and usages of the people, and finally reduced to a more regular system in 1794. The magistracy, in the rural districts, is still a patrimonial right, vested in owners of particular estates; but the power formerly possessed by them has been contracted within narrower limits than formerly. The judgment of those lower courts is not final, except in very trifling cases, and an appeal may be made to the tribunals of the second instance, which are established in the several provinces, and to whom is attached the superintendence of the colleges for imparting legal knowledge to pupils. These tribunals of the second instance, or *Oberlandesgerichten*, have the duty of promulgating the laws, of watching over the interests of lunatics and minors, as well as of deciding processes. They are usually divided into two portions, one of which attends to the appeals from the inferior courts, and the other pronounces sentence on such civil and criminal cases as originate in them. In the provinces on the Rhine, the legal code of Napoleon is yet in force, but in a short period, the Prussian system is to be extended over those districts. From all the *Oberlandesgerichten* appeals may be brought before the high College of Justice in Berlin, whose decisions are final. The Prussian system of law is more simplified than most of those of feudal origin, and in its practice it is expeditious, economical, and uniform. The Police is under separate jurisdictions, and in the country, the *Landraths* resemble, in some measure, our petty sessions of justices of the peace. In the cities are peculiar Boards appointed, under whose direction the regulation of buildings, sewers, and the supplies of water and of food, are placed. The police has the superintendence of the examination of those who are licensed to practice the medical profession; of the assurance offices against losses by fire, and of the engines and other implements to prevent fires from extending. To this is added the keeping a watchful eye on all individuals who have no visible means of subsistence. In all the cities, the police is mildly and regularly administered, with more attention to the prevention than the punishment of crimes.

Education.

Few of the nations of Europe have, within the last two centuries, exceeded Prussia in the number and eminence of its men of learning, or in the various establishments for the promotion of science and literature that have been founded. In no other country is the instruction of the lower classes so sedulously provided for; and in none are there so few persons who are ignorant of the first rudiments of knowledge. With the exception of those provinces which formed a part of the French empire, where inattention to popular instruction prevailed to a great degree, and to which the system of Prussia is not yet extended, no village is without its school, in which reading, writing, and arithmetic, are taught, and moral and religious principles inculcated. Next to the village are burgher schools, where the pupils are taught the first elements of knowledge, and prepared for admission into institutions called Gymnasiums, similar to our great schools of Winchester, Eton, Westminster, and Edinburgh. In these, classical learning is pursued to a great extent, as preparatory to admission into the universities. The number of these gymnasiums is 105; some under the direction of the Protestants, others under that of the Catholics, and some few under a combined direction of both sects. They have, according to their extent, from four to twelve masters; and the pupils are divided into five or six classes; the lower of which differ but little in their pursuits from the burgher schools. In the larger and middle sized cities, schools are established for the instruction of the females, with which, in Silesia, are combined, among those of the lower class, the teaching the delicate art of lace-making. The universities, like those of the other parts of Germany, are either endowed, or the expences of the professors and libraries are defrayed by the government. The course of study is left much to the choice of the students, and is, therefore, too much influenced by the temporary popularity of particular professors. The means of instruction in every branch of science and literature is abundantly furnished; and, in spite of the want of discipline which generally prevails, the foundation is laid in them of those eminent acquirements in which the students have afterwards

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distinguished themselves in the various walks of science and literature. The universities are, Berlin, with 50 professors and 950 students; Breslau, 51 professors and 366 students; Geifswalde, 28 professors, 158 students; Halle, 51 professors, 500 students; Königsberg, 43 professors, 210 students; and Bonn, instituted in 1818, with 22 professors and 240 students. There are seminaries for the instruction of the village schoolmasters in fourteen of the cities; as well as theological academies for the Catholics, Lutherans, and Moravians, unconnected with the universities, where the clergy of the different parties receive the appropriate instruction to qualify them for the duties of their functions. Besides these are useful establishments for pupils in medicine, surgery, midwifery, the veterinary and military professions, rural economy, and for teaching the deaf and dumb, and the blind.

Libraries.

The collections of natural history, the philosophical and astronomical apparatus, and the public libraries, are upon a very liberal footing, and at the service of any individual who wishes to avail himself of their help. The libraries of Berlin, thus open to general use, contain more than 300,000 volumes; those of Breslau more than 100,000; Halle more than 50,000, and in the other cities are generally to be found large collections.

State of the Press.

The freedom of the press has been of late somewhat restrained, as far as relates to fugitive and periodical publications of the smaller class. All books must pass under Censors previous to publication; but works of science are allowed to pass with scarcely any inspection; and there is no restriction on bringing into Prussia any works published in any of the other states of Germany. The universities have an unlimited right of printing without a previous censurate. Thus, with the exception of the political writings of the lowest character, the practical freedom of the press is enjoyed to a greater extent than in any other country except Great Britain. In the year 1819, the newspapers were, sixty-two government weekly papers, which contained little but domestic intelligence and advertisements; fifteen political papers, written by individuals, but with much reserve; and one literary journal.

Money.

The currency of Prussia consists of metallic and paper money, but the former is so much greater in amount, that the latter suffers no depreciation. The metallic money is estimated to amount to 30,000,000 *reichs thaleren*; the paper money, including that of a privileged company (*see Handlung obligationem*), does not amount to more than 5,000,000, and by means of a sinking fund, is gradually diminishing, and will soon be extinct. The money is coined in Berlin, Breslau, and Dusseldorf. The gold coins are double, single, and half Frederick Williams d'ors, valued at 10d. 5d. and 2½d. reichs thalern. The silver coins are the thaler, half thaler, third, sixth, and twelfth of the thaler. The copper and mixed metal coins are groschen, sechser, drier, and pfenninge. In the old provinces, accounts are kept in dollars (thalern), groschen, and pfenningen. Twelve pfenningen make a grosch, and twenty-four groschen a dollar. The value of the dollar in exchange with London varies from 3s. to 3s. 2d. In the other provinces, the accounts are kept in various denominations of money; but they are easily reduced into florins or gulden; three of which are equal to two dollars, and whose value in exchange with London is about two shillings.

Weights and Measures.

The legal long measure of Prussia is the Berlin ell of two feet, which contains $25\frac{3}{8}$ Rhenish inches, or 296 French lines. In the distant provinces, a local measure of length prevails, which differs in each. The Prussian mile is 23,685 feet, or nearly the same as the German geographical mile, or one-fifteenth of a degree of latitude, being somewhat less than $4\frac{1}{2}$ English miles. The land measure is the Magdeburgh morgen of 180 roods, each rood of 12 feet; the foot is about one-seventh longer than the English, thus a morgen is nearly two-thirds of an English acre. The dry measure is the Berlin scheffel of $2{,}758\frac{20}{21}$ Parisian cubic inches, or nearly one bushel, one peck, and one gallon English measure. The liquid measures are more various than any other, and differ in every province; but as they are all legally reducible to Berlin measure, we give that, viz. a oxhoft is six eimer, an eimer two ankers, an anker thirty-two quarts, the quart two nöseln. The quart contains 58 Parisian cubic inches, or nearly one-ninth less than the English quart. The weights of commerce are the shipslast, containing 12 shipspounds. The shipspound contains 280 common pounds. The centner of 110 pounds is divided into light and heavy stones, having ten of the former and five of the latter. The pound is divided into two marks, the marks into sixteen loth, the loth into four quentchen, the quentchen into four pfenninge.

See Stein's *Landburch der Preuss*, Berlin, 1818; *Statistische Darstellung der Preusische Monarchie*, von J. A. Demain, 1818; *Uebersicht der Bodenflache und Bevolkerung des Preusiche Staats, aus den für das Jahr*, 1817, *Eingezognen Nachrichten*, 1818; Heidemann, *Handbuch der Postgeographie der Königl, Preuss Staaten*, 1819; Jacob's *View of the Agriculture, &c. of Germany*, London, 1820.

(W. W.)

QUA

Quakers.

QUAKERS.—Under this head, the *Encyclopædia* contains an account of the tenets of the Society of Friends, commonly called Quakers, extracted from a *Summary of the History, Doctrine, and Discipline* of that Society, published by authority. The article is prefaced with some observations on the character of George Fox, copied, seemingly, from the theological writings of the celebrated polemic, Charles Leslie, which appear to have given offence to the Society; as well on account of their alleged unfairness, as on account of the impropriety of reviving and circulating them in a work so generally referred to by all classes of the community. These observations have been accordingly subjected to some pointed animadversions in a piece entitled, *A Refutation of the more modern Misrepresentations of the Society of Friends*, written by Joseph Gurney Bevan; and as we have been requested to notice this piece, and have been also furnished with some additional strictures on the article in question, we think it right to take the present opportunity of stating the substance of the remarks, printed and manuscript, that have been laid before us in regard to it. It would be worse than uncourteous to refuse this satisfaction to a Society so highly respectable, so moderate in controversy, and which has so often distinguished itself by its generous and persevering efforts in the cause of truth and humanity.

The observations complained of, in regard to George Fox, the founder of this Society, are not merely such as tend to disparage his intellectual character, by representing him as a fanatic and enthusiast; representations of that kind Quakers are accustomed to, and can bear in silence; but they are such as represent him arrogating to himself a superhuman nature, and even blasphemously designating himself as "Christ," and "the Son of God." In support of these statements, reference is made in the *Encyclopædia* to three different pieces, all of which are quoted as undoubted productions of Fox. The first of them is entitled *The Battledoor for Teachers and Professors*, in the introduction to which, the writer says, "All languages are to me no more than dust, who was before languages were;" the second, *News coming up out of the North sounding towards the South*, in which Fox is represented as saying of himself, "I am the same door that ever was: the same Christ yesterday, today, and for ever;" and the third, a *Letter to Cromwell*, in which Fox in like manner says of himself, "Him whom the world calls George Fox, who is the Son of God."

With regard to the *Battledoor for Teachers and Professors*, it has been observed, first, that it is by no means correct to refer to it as being exclusively, or even chiefly written by Fox. On the contrary, it appears to have been compiled, with some assistance from him, by two of his friends; a circumstance wholly overlooked by the writer of the article in the *Encyclopædia*. It is thus mentioned by Fox, in that singular work, the *Journal of his Life*. "When I was prisoner in Lancaster Castle, the Book called the *Battledoor* came forth, which was written to show, that in all languages *thou* and *thee* is the proper and usual form of speech to a single person, and *you* to more than one. This was set forth in examples or instances taken out of the Scriptures, and out of books of instruction in about thirty languages. John Stubbs and Benjamin Furly took great pains in compiling it, which I put them upon; and some things I added to it."* Now, unless it could be shown, that the objectionable words quoted from this piece were "some of the things added" by Fox, there is evidently no reason for imputing them to him rather than to Stubbs or Furly. The author of the *Refutation* adds the following observations by way of apology for the passage, whether written by Fox, or by one of his coadjutors. "I have granted that the expression 'all languages are to me no more than dust, who was before languages were,' is liable to exception; but I think when we construe it by the context, the fairest way of interpreting that which is obscure in the writings of deceased authors, some of the difficulty ceases. It should be remembered that the main tenet, on which George Fox and his friends insisted, was the infinite superiority of the Spirit to the Letter. The learned of that day, as of other times, valuing themselves on their knowledge

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* The sequel of the passage is curious. "When it (the *Battledoor*) was finished, some of them were presented to the King and his Council, to the Bishops of Canterbury and London, and to the two Universities, one a-piece; and many bought of them. The King said, 'It was the proper language of all nations.' The Bishop of Canterbury, being asked what he thought of it, was so at a stand that he could not tell what to say to it. For it did so inform and convince people, that few afterwards were so rugged towards us for saying Thou and Thee to a single person, which before they were exceeding fierce against us for. For Thou and Thee was a sore cut to proud flesh, and them that sought self-honour; who, though they would say it to God and Christ, would not endure to have it said to themselves. So that we were often beat and abused, and sometimes in danger of our lives for using those words to some proud men, who would say, 'What! you ill-bred clown, do you Thou me!' as though there lay Christian breeding in saying You to one, which is contrary to their grammars and teaching books, by which they instructed their youth."—*Journal*, p. 328. 3d edit. folio, London, 1765.

Quakers. of languages, despised our Friends for their ignorance; these in return frequently decried human learning, to a degree in which, probably, they would not have slighted it, if they had not thought it to be set too much in competition with the knowledge of divine things, which they believed the soul to receive by immediate internal communication with the Mediator, Christ." "All languages are to me no more than dust, who was before languages were." (The writer immediately goes on,) "and am come'd before languages were, and am redeemed out of languages into the power where men shall agree; but this (meaning the *Battledoor*) is a whip and a rod (alluding to the correction of children) to all such who have degenerated through the pride and ambition from their natural tongues and languages, and all languages upon the earth is but natural, and makes none divine, but that which makes divine is the word, which was before languages and tongues were."—*Refutation*, p. 39, 40.

The most serious charge against Fox, that of assuming the name of the Saviour, and impiously designating himself as "the Son of God," in so far as it is founded upon his acknowledged piece, entitled, *News coming up out of the North*, appears to us to have been most unfairly made; and to require no other refutation but the simple inspection of the passage in which these words occur. We here copy it verbatim, with all its palpable defects of grammatical
John 1. 1. construction and punctuation: "Now to all dear ones, and dear hearts, I speak, the same seed, which is Christ, the same spirit takes upon it now as ever was, the same world is now as ever was, the same temptations, and the same Divels, and the same worship of the world, twining into another form and colour, but Jesus Christ is the way, the truth and life, he is the
John 14. 6. door that all must passe through, and he is the por-
John 10. 3. ter that opens it; I am the same door that ever was,
Luke 11. 34. the same Christ to day, yesterday and for ever." * It is abundantly clear, as well from the context of this uncouth passage, as from the references to the gospels affixed to the words upon which the charge against Fox is made, that he is not here speaking in the first person, but copying certain expressions, used by Christ himself, in the texts referred to. We cannot conceive it possible for any rational person to entertain a doubt upon this point; and the use which Leslie has made of the passage, can be viewed in no other light than as an instance of that blind zeal and gross unfairness which has often disfigured theological controversy.

The charge, in so far as it rests upon a *Letter to Cromwell*, does not admit of so direct a refutation. It is certain, that Fox, after being apprehended and brought to London, upon suspicion of being concerned in some plot, did address himself by letter to the Protector, with a view to satisfy him, that he was not a person at all likely to take arms against the government. Fox himself gives the *substance* of the letter, and some graphical details of the interview which followed it, in his *Journal*; † but the letter itself is not inserted; and it has never, it is said, appeared any where but in one of Leslie's pieces against the Quakers. It there appears, with an attestation of its authenticity, signed by two persons, who mention their having seen it delivered by Fox to the messenger who carried it to Cromwell. But the Society, notwithstanding, seem very unwilling to admit the genuineness of this letter and its attestations; at least, of the passage in which Fox designates himself as "the Son of God." ‡ It cannot, however, be denied, that the letter, as published by Leslie, corresponds pretty exactly with Fox's own account of its contents, given in that part of his *Journal* above referred to. But, granting that the words in question really made a part of it, we should be inclined to consider them rather as exemplifying some awkward elliptical reference to scripture, or as a specimen of the mystical jargon then prevalent, than as indicative of any intention in Fox to apply them literally to himself. Every page, almost, of his *Journal*, contains proofs of his ardent belief in the Divinity of Christ; and, whatever other fancies he may have entertained, it seems, therefore, quite absurd to speak of him as one who fancied himself possessed of the name or nature of the Saviour.

Penn and Barclay, the most generally respected names among the early Quakers, are alluded to in the article in the *Encyclopædia*, in a way which seems to imply, that their creed differed from, and was more rational than that of Fox, and that they did not altogether approve of his ministry. The information laid before us, however, bears, that there was a strict conformity in their tenets; that they

* *Newes coming up out of the North sounding towards the South*, p. 15. 4to. Lond. 1655.

† "I spoke much to him (Cromwell) of truth; and a great deal of discourse I had with him about religion, wherein he carried himself very moderately. As I was turning, he catched me by the hand, and with tears in his eyes, said, 'Come again to my house; for if thou and I were but an hour of a day together, we should be nearer one to the other;' adding, that he wished me no more ill than he did to his own soul. I told him, 'If he did, he wronged his own soul; and admonished him to hearken to God's voice, that he might stand in his counsel, and obey it; and if he did so, that would keep him from hardness of heart; but if he did not hear God's voice, his heart would be hardened.' He said, It was true. Then I went out; and when Captain Drury came out after me, he told me his Lord Protector said, I was at liberty, and might go whither I would. Then I was brought into a great hall, where the Protector's gentlemen were to dine. I asked them, What they brought me thither for? They said, it was by the Protector's order, that I might dine with them. I bid them let the Protector know, I would not eat of his bread nor drink of his drink. When he heard this, he said, 'Now I see there is a people risen, that I cannot win either with gifts, honours, offices, or places; but all other sects and people I can." *Journal*, p. 127, 128.

‡ See the observations upon this point in Bevan's *Refutation of Modern Misrepresentations*, p. 43, 44.

Quakers ‖ Queen's County.

often preached them in conjunction, and in the most interesting circumstances, in perfect accordance;* and that Fox was always held in the highest respect by both of his associates.

Situation and Boundaries.

QUEEN'S COUNTY, a county in the province of Leinster, in Ireland, bounded by Kildare on the north, Carlow on the east, Kilkenny and Tipperary on the south, and King's County on the west; about 32 English miles long, and 25 broad, and containing about 600 square miles, or 384,000 English acres. It is divided into eight baronies and 50 parishes, the latter belonging to the Sees of Leighlin, Ossory, Kildare, and Killaloe. Portarlington, its principal town, on the northern side of the county, is situated in north latitude 53° 9′ 30″, and west longitude 7° 13′.

Surface.

Excepting on the boundary with King's County, where the Sliebh-bloom mountains rise to a considerable height, this district is generally level; so much so, that, notwithstanding considerable tracts of bog, about three-fourths of the whole are said to be cultivated. The soil, though various, is for the most part fit for producing all the usual crops: and limestone for manure abounds in every townland. In the south-eastern quarter, near Carlow, coal, similar to that of Kilkenny, is wrought to a considerable extent; and iron ore, sandstone, marble, with marl, and a variety of clays, have been found in various parts. Besides a number of small streams, it has two considerable rivers, the Barrow and the Nore, which, having their source among the mountains on the west, flow, the former north-east and then south, and the latter south-east, until they meet at New Ross, in the county of Wexford, after which they are joined by the Suir from the west, and fall into the sea at Waterford Bay. Next to the Shannon these are the most considerable rivers in Ireland. The Barrow is navigable from New Ross upwards to Carlow and Athy, from which the communication is continued by a canal to Dublin. The Nore is also navigable for a few miles, but not in this county. After their junction at New Ross, there is water sufficient for large ships downwards to the sea. Queen's County, therefore, though an inland district, has the advantage of ready access by water both to the east and south coasts of Ireland.

Minerals.

Waters.

Estates.

Much of this county is divided into large estates, worth from L. 5000 to L. 15,000 a-year and upwards. Some of the most valuable, having been let on perpetual leases, afford a large income to the lessees. It is these lessees who form the middle class of gentry, with clear incomes of from L.100 to L.800 *per annum*, obtained from tenants to whom their lands are subset at rack-rent, and commonly in very small farms. These leases are usually for 21 years and a life. The principal proprietors are the Marquis of Drogheda; Lords De Vesci, Ossory, Ashbrooke, Stanhope, Castlecoote, and Portarlington; Sir Charles Coote, Mr Parnel, Mr Strange, and Mr Wellesley Pole, now Lord Maryborough. Here and in King's County, Mr Wakefield observed some of the best farming in Ireland, with much more attention to a systematic course of cropping, and to keeping the land in good heart. Oxen and horses are used for the plough, the former generally preceding the latter. A good deal of cheese is made here for the Dublin market. In other respects the rural economy of this district does not differ materially from that of the Irish counties already described.

Queen's County ‖ Quesnay.

Towns.

There is no large town in Queen's County. Maryborough, the county town, though pleasantly situated near the Barrow, is a place of no consideration. Portarlington, partly in King's County, noted for its schools, and for its being the residence of the smaller gentry, is the most extensive and populous. Mountmellick, Mountrath, Ballynakill, and Stradbally, are only villages. The manufactures are linen and coarse woollens, to no great extent; and its exports chiefly corn and other kinds of land produce.

Population, &c.

In 1813 the number of inhabitants was 113,857; in 1821 the number was 129,391, making an increase of 15,534. The county sends two members to Parliament, and the town of Portarlington a third. Before the Union, this district had eight representatives in the Irish Parliament; two for each of the boroughs of Portarlington, Maryborough, and Ballynakill, and two for the county. The Irish language is still spoken in some parts, though the English is now more common. A few years ago, the wages of common labour were one shilling a-day for men and sixpence for women; their food is potatoes, their fuel turf or peat, and their clothing, excepting that of the females on holidays, the produce of their own domestic manufacture.

See the general works quoted under the former Irish counties, and Sir Charles Coote's *Agricultural Survey of Queen's County*. (A.)

QUESNAY (FRANÇOIS), a physician of considerable eminence, but who is chiefly known in the history of philosophy as a profound and ingenious inquirer into the constitution of society, and as the founder of the sect of the Economists.

The accounts of the life of this distinguished person—a life which, unlike that of most literary men abounded in incident and adventure—are exceedingly meagre and contradictory.—Neither the place of his birth, nor the condition of his parents, is well ascertained; but the accounts apparently most enti-

* In 1677, Penn, Barclay, Keith, and others, crossed over to Holland, where they preached, or discoursed together before numerous assemblages of the people.—"This being first-day, we had a very large meeting, there coming to it a great concourse of people of several opinions, Baptists, Seekers, Socinians, Brownists, and some of the Collegians. Robert Barclay, George Keith, William Penn, and I, did all severally declare the everlasting truth among them; opening the state of man in the fall, and shewing by what way man and woman may come into the restoration by Christ Jesus. The mystery of iniquity and the mystery of godliness were very plainly laid open, and the meeting ended quietly and well." *Journal*, p. 502. 3d edit. fol. Lond. 1765.

Quesnay.

tled to credit state that he was born at the village of Ecquivilly, in the Isle de France, in 1694; and that his father was either a common labourer, or a small proprietor, who cultivated his own little property.* His humble origin is indeed evident from the fact mentioned by all his biographers, of his early education being almost entirely neglected, and of his being constantly occupied, until his fourteenth or sixteenth year, in the sports or labours of the fields, without having been either sent to school or taught to read. But though placed in such unfavourable circumstances, young Quesnay was embued with an ardent love of knowledge, and with a strong desire to emerge from the painful and obscure life in which he had been brought up. The *Maison Rustique* of Liebaut was the first book that came into his hands; and he is said to have learned to read it by the assistance of a few lessons he received from a gardener of the village! The perusal of this book, which seems to have had a material influence on his future studies, awakened his latent powers, and stimulated him to make further efforts to extend his information. Having acquired a competent knowledge of his vernacular tongue, by the eager reading of such French books as came within his reach, he next applied himself to the study of the dead languages; and speedily attained, partly by the slender assistance of a self-dubbed surgeon of the village, but chiefly by his own extraordinary industry and sagacity, to a tolerable proficiency in Latin and Greek.

Quesnay now resolved, in opposition to the wishes of his parents, and especially of his mother, to devote himself to the profession of surgery, and received the rudiments of his instruction in that art from the village doctor who had assisted him in his philological studies. But the pupil very soon surpassed the master; and when the latter applied to be admitted into the *Maitrise*, or Corporation of Surgeons, he presented, as testimonials of his skill in his profession, and of his capacity to practise it with advantage, some Essays which Quesnay had written, and which were received with very great applause. Quesnay was not privy to this *ruse;* but soon after its occurrence he left his paternal village, and set out to prosecute his studies at Paris. We are not informed by what means he supported himself in that city, nor how long he remained there: while, however, his indefatigable industry and zeal enabled him to make great progress in his studies, his merit and modesty procured him several friends. Besides attending the prelections on the various branches of surgery, and the different hospitals, he found leisure to devote some portion of his time to metaphysical researches, and the study of philosophy, for which the perusal of the *Recherche de la Verité* of Malebranche had given him a very decided taste. Nay, such was the almost unparalleled activity and vigour of his mind, that having accidentally met, during his stay in Paris, with the celebrated M. Cochin, of the Royal Academy of Painting, he put himself under his tuition; and we are told, that he profited so well by the few lessons he received as to be able not only to take remarkably good likenesses, but to design and *engrave*, with his own hand, the various bones of the human skeleton, in a manner which would not have disgraced the most skilful artists!

On finishing his studies at Paris, Quesnay formed the design of establishing himself as a surgeon in Mantes, a considerable town in his native province, and presented himself to the surgeons of its *Maitrise* for examination. But they refused, from jealousy of his talents, to admit him to trial. He was thus laid under the necessity of returning to Paris, where he passed his examinations with eclat; and received letters ordering him to be admitted into the Maitrise of Mantes in 1718.

Having established himself at Mantes, his reputation soon extended itself. He was employed by some of the first families in the neighbourhood, and, among others, by that of the Marshall de Noailles, Duc de Villeroi, who persuaded him to leave his residence in the country, and to accompany him to Paris as his surgeon, as nearly as we can collect in 1729 or 1730. An incident not long after occurred, which had the most material influence on his future prospects and life. Having accompanied the Duc de Villeroi to the house of the Comtesse d'Estrades, Quesnay remained behind in the carriage while the Duc went in to visit that Lady, who, during the interview, was suddenly seized with an epileptic fit. The Duc called in Quesnay, who, on perceiving the nature of the attack, with singular presence of mind instantly ordered the Duc and the other attendants out of the room, and managed so well as to succeed in concealing the malady. The Comtesse was so much pleased with the dexterity and address of Quesnay, that she lost no time in recommending him to her all-powerful friend, Madame d'Estioles, afterwards Marquise de Pompadour, who made him her physician: and, besides obtaining for him apartments at Versailles, procured him, in 1737, the place of Surgeon in Ordinary to the King.†

Quesnay.

* It is stated in the *Eloge Historique* of Quesnay, in the *Memoires de l'Academie des Sciences* for 1774, that he was the son of an *advocat en Parlement,* who practised at Montfort, and that he was born at Merey. But it is difficult to suppose, had his father been in such a station, that his education would have been so entirely neglected. In the brief but interesting notice of Quesnay, given by Mr Crawfurd, in a note to the *Journal* of Madame du Hausset, femme-de-chambre de Madame de Pompadour, et *l'amie* de Quesnay, in the *Melanges d'Histoire et de Literature* (p. 276), he is stated to have been the son of a labourer. This is also the statement in the *Encyclopedie Methodique.* According to the *notice* prefixed by Dupont to the *Eloge* of M. Gournay in the third volume of the *Œuvres de Turgot,* Quesnay was the son d'un *proprietaire cultivateur.*

† This incident is related by Mr Crawfurd, *Melanges,* p. 276, and is referred to by Marmontel.

Quesnay was shortly after appointed Secretary to the Royal Academy of Surgery, established in 1731; and besides several articles on particular branches of surgery, he contributed the preface to the first volume of its *Memoires;* which has always been reckoned peculiarly valuable for its profound and discriminating observations on the respective uses of theory and observation in the physical sciences, and on the assistance which they reciprocally lend to each other.

Having from an early period been much subject to the gout, and becoming, in consequence, less able to discharge his duties as a surgeon, Quesnay took the degree of Doctor of Medicine in 1744; and was soon after appointed, through the influence of his patroness, to the important place of consulting physician to his Majesty. In this capacity he attended Louis in the campaigns of 1744 and 1745; and amid the distractions of a camp, collected and prepared the greater part of the materials for his *Traité de Fievres,* published in 1753.

His appointment to the situation of Physician to the King was preceded by the grant of letters of nobility, issued on occasion of the recovery of the Dauphin from the small-pox. Louis, who was much struck with the justice and solidity of Quesnay's remarks, and who familiarly called him *son penseur,* gave him, in allusion to this title, three pansey flowers (in French pensées), for his arms, with the motto *Propter cogitationem mentis.*

The leisure Quesnay now enjoyed, enabled him to prosecute his studies with greater assiduity. In 1747, he republished an enlarged edition, in 3 tomes. 12mo, of his *Essai Physique sur l'Economie Animale,* originally published in 1736; in 1748, he published an *Examen impartiel des Contestations des Medicins et des Chirurgiens de Paris;* in 1749, he published a *Memoire sur la Sagesse de l'Ancienne Legislation de la Chirurgie en France,* and two separate treatises, in 12mo, the one on *Suppuration,* and the other, *De la Gangrene;* in 1750, he republished his *Traité des Effets et de l'Usage de la Saignè,* written during his residence at Mantes, and originally published in 1730; and in 1753, he published his *Traité des Fievres Continues,* in 2 tomes 12mo.

These works have been all held in very high estimation; and an excellent judge has lately given it as his opinion, that "the *Traité de la Gangrene* is by far the most valuable publication which we yet possess upon this subject." Every page of this work, he adds, "is distinguished by the same talent for accurate observation, and perspicuous arrangement, which are so remarkable in all the other writings of this celebrated author." (Dr Thomson's *Lectures on Inflammation,* p. 502.)

The *Traité des Fievres* was the last of Quesnay's professional works. He appears to have henceforth comparatively abandoned his medical studies. At no period, indeed, had he allowed them exclusively to occupy his attention, and he now devoted himself, in preference, to other and, if possible, still more interesting inquiries. He had always entertained a strong predilection for agricultural pursuits, the effect, perhaps, of his situation in early life; and this, combined with the speculative and metaphysical cast of his mind, seems to have led him to those peculiar notions respecting the paramount importance of agriculture as a source of wealth, and the constitution of society, which have rendered his name so justly celebrated in the history of economical science. The articles "*Fermier*" and "*Grains*" in the *Encyclopedie,* published in 1756 and 1757, contain the earliest developement of his views on this subject. Both articles are written with great ability, and display an intimate acquaintance with the subject, considerable reading, and great powers of analysis. In the article "*Grains*" the distinction between the *produit total* and the *produit net,* between the productiveness of agriculture, and the unproductiveness of all other employments, the doctrine of the unrestricted freedom of commerce, and most of the other leading principles in the theory of the economists, are distinctly stated and illustrated with much ingenuity and talent. The TABLEAU ECONOMIQUE, and the *Maximes Generales du Gouvernement Economique,* annexed to it, under the title of *Extraits des Economies Royales, de M. de Sully,* were printed, by the express command of the King, at Versailles in 1758, with the following very remarkable epigraph for a work brought forth under such auspices, *Pauvres paysans, pauvre royaume; pauvre royaume, pauvre Souverain!* The maxims, which contain a short but comprehensive abstract of Quesnay's system, were reprinted, together with an analysis of the *Tableau,* and a selection from various articles contributed by Quesnay, in defence of his peculiar doctrines, to the *Journal d'Agriculture,* and the *Ephemerides du Citoyen,* * in the collection of Quesnay's economical works, entitled *Physiocratie, ou Constitution Naturelle du Gouvernement le plus Avantageux au Genre Humain,* edited by his friend and scholar, Dupont, in 1767.

We have elsewhere entered at considerable length into an examination of the speculations of Quesnay and his followers, with respect to the constitution of po-

* The *Ephemerides du Citoyen* was begun in 1767, and was, for a few months, conducted by the Abbé Baudeau, and then by Dupont. It was published monthly, and two numbers make a considerable duodecimo volume. The authors were all disciples of Quesnay, and zealous economists. Their discussions embraced only the moral and political sciences; many branches of which they have treated with much ability and acuteness. There is a valuable *Eloge* of Quesnay in one of the numbers for 1775, written by the Conte d'Albon. The following extract from the *approbation* given by the *Censeur* to the third number for 1770 is curious: "J'exhorte," says he, "de nouveau les auteurs de ce *Journal,* à resister à la tentation de critiquer—Le bonheur du citoyen tient à sa confiance—On peut et l'on doit quelquefois avertir en secret ceux qui sont preposès à l'administration. *Mais on ne doit prêcher aux particuliers que leur propre reforme, et non celle de l'etat.*"

Quesnay.

litical societies, and the sources of public wealth. (See the articles ECONOMISTS and POLITICAL ECONOMY.) That there is a good deal of error in them must be allowed; but this is far more than compensated by the many just, discriminating, and original views, and important discoveries, which they contain. Perhaps, however, the principal merit of Quesnay, and the sect of which he was the founder, does not consist so much in the discoveries they made, as in their having been the earliest philosophers who perceived that the institutions of society ought always to harmonize with the natural principles on which it is founded, or, as they termed it, with the *Ordre naturel et essentiel des Societes Politiques*. Economical science is defined by them to be, "*L'etude et la demonstration* DES LOIX DE LA NATURE, *relatives à la subsistence, et la multiplication du genre humain.* L'observation universelle de ces loix est l'interet commun et general de tous les hommes. La connaissance universelle de ces loix est donc le preliminaire indispensable, et le moyen necessaire du bonheur de tous." (*Ephemerides du Citoyen*, 1769, No. II. p. 13.) It is to be regretted that, in investigating these laws, they proceeded almost entirely on abstract and speculative principles, without sufficiently attending to the effects of particular institutions, and to the various phenomena manifested in the progress of society. But notwithstanding the defective mode in which the economists conducted their researches, they succeeded in establishing and elucidating many important principles; and there is certainly much more reason to wonder at the general correctness of their conclusions, than to feel surprised at the errors into which they fell. Quesnay and his disciples established, that society was formed for the purpose of securing the greatest possible advantage to its members; that the security of property and the freedom of industry were its essential bases; and that the proper business of the politician was not to interfere to regulate the pursuits of individuals, but to protect the equal rights and liberties of all, and to secure the utmost freedom of competition in all the departments of industry. And though it is undoubtedly true, that most of these principles had been pointed out by previous writers, Quesnay and his school have the unquestionable merit of being the *first* who showed their dependence on each other, who presented them in a *systematic and consentaneous form*, and who were thus enabled to give a scientific demonstration of the injustice and impolicy of such institutions as ignorance or mistaken views of national interest had established in opposition to them.

In our article on Political Economy we have shown the fallacy of Quesnay's opinion with respect to agriculture being the only source of wealth; and the experience of all ages sufficiently proves that the *despotisme legal*, in the hands of an hereditary monarch, without *contreforces* of any kind, which he strangely supposed was the best of all possible governments, is about the very worst. *

Notwithstanding his great age, and the sufferings he experienced from the almost incessant attacks of the gout, the activity of Quesnay's mind continued unimpaired. *Il a*, said one of his friends, *une tete de trente ans sur un corps de quatre-vingts.* He contributed, subsequently, to the publication of the *Physiocratie*, many acute and able articles to the *Ephemerides du Citoyen*; and continued wholly occupied with these studies and mathematics, to which he had latterly begun to pay considerable attention, till his death, which took place at Versailles, in December 1774, in the 80th year of his age.

Quesnay was a man of the most inflexible integrity; the nicest sense of honour; and the greatest prudence and discretion. Though highly esteemed by the King, and long resident at Court, he never intermixed in the intrigues of which it was the constant theatre. No one ever scrupled to express himself freely in his presence, nor was the confidence placed in him ever betrayed. "Il recevoit chez lui des personnes de tous les partis, mais en petit nombre, et qui toutes avoient une grande confiance en lui. *On y parloit tres hardiment de tout; et ce qui fait leur eloge et le sien, jamais on na' rien repèté.*" † To the utmost frankness and sincerity, he added the easy address and polished manners of a courtier and the intelligence of a philosopher. No man was ever less solicitous of distinguishing himself, or more careful to offend the self-esteem of others. His conversation was animated, without the least effort at brilliancy. So much, indeed, was he averse to every appearance of pretension, that he was in the habit of veiling the most profound remarks and observations, under the form of apologues, which generally referred to some subject connected with rural affairs, to which he was always particularly attached. He was most indulgent to the faults and errors of others, provided they were unalloyed by any taint of artifice or baseness, for which he never hesitated, whatever might be the rank of the party, to express the utmost contempt. Quesnay was truly a patriot and a philosopher. And we doubt much whether another instance can be produced of one who had lived so long in a profligate and luxurious Court, unsullied by its vices, and aloof from its contentions; and who preserved, to an extreme old age, all those generous and kindly feelings, with that unobtrusive but ardent zeal in the cause of humanity, and that love of speculation and profound inquiry, which distinguished his earlier years.

Quesnay, says Madame du Hausset, "etoit un grand genie, suivant l'opinion de tous ceux qui

* We are at a loss to conjecture the grounds on which Mr Chalmers has presumed to affirm (*Biographical Dictionary*, Vol. XXV. Art. Quesnay), that the "economists abused their influence by circulating democratical principles!" It would be quite as correct to say, that Locke and his followers had abused their influence, by circulating *despotical* principles.

† *Journal de Madame du Hausset in the Melanges, &c.* p. 277. A striking instance of the confidence placed by the most opposite parties in Quesnay is given in the second volume of Marmontel's *Memoirs.*

Quesnay || Radnorshire.

l'avoit connu et de plus un homme fort gai. Il aimoit causer avec moi de la campagne; j' y avois été elevée, et il me faisoit parler des herbages de Normandie et du Poitou, de la richesse des fermiers, et de la maniere de cultiver. C'etoit le meilleur homme du monde, et la plus eloignè de la plus petite intrigue. Il etoit bien plus occupe à la cour de la meilleure maniere de cultiver la terre que de tout ce que s'y passoit." (*Melanges*, p. 343.)

"Tandis," says Marmontel, "que les orages se formoient et se dissipoient au-dessous de l'entresol de Quesnay, il griffonnoit ses axiomes et ses calculs d'économie rustique, aussi tranquille, aussi indifférent à ces mouvemens de la cour, que s'il en eût été à cent lieues de distance. Là bas, on décidoit de la paix, de la guerre, du choix des généraux, du renvoi des ministres; et nous, dans l'entresol, nous raisonnions d'agriculture; nous calculions le *produit net*, ou quelquefois nous dînions gaiement avec Diderot, d'Alembert, Duclos, Helvétius, Turgot, Buffon; et M.me de Pompadour, ne pouvant pas engager cette troupe de philosophes à descendre dans son salon, venoit ellemême les voir a table et causer avec eux."

Dr Smith was well acquainted with Quesnay. He frequently met with him during his residence at Paris in 1766; and while he bears the most honourable testimony to the "modesty and simplicity" of his character, he has pronounced his system to be, "with all its imperfections, the nearest approximation to the truth that has yet been published on the subject of Political Economy." (*Wealth of Nations*, Vol. III. p. 28.) So highly, indeed, was Dr Smith impressed with a sense of his merits, as a man and a philosopher, that it was his intention, had he not been prevented by Quesnay's death, to have inscribed to him the *Wealth of Nations*. (Mr Stewart's *Account of the Life and Writings of Dr Smith*.)

Quesnay had a son by his wife, to whom he was united when at Mantes. He gave him an excellent education; and exhibited a striking proof of his disinterestedness, by constantly refusing to solicit for him any place or situation under government. This son ultimately settled in the country on an estate near Beauvoir. One of Quesnay's grandsons was appointed by Turgot to a place in the administration; and another entered the army, and acted as a captain of infantry at the battle of Jemappes.

No man was ever more esteemed by his friends than Quesnay, and none ever existed who was more ready to do all in his power to advance their interests. Mercier de la Riviere, the author of the work *Sur l'ordre Naturel et Essentiel des Sociétés Politiques*, and who had been *Intendant* at Martinique, seems to have occupied the chief place in his esteem, and was regarded by him as the only person in France who was qualified to conduct the administration of the Finances. He was also much attached to the Marquis de Mirabeau, Turgot, Dupont, the Abbé Baudeau, and the other leading economists, who willingly acknowledged him for their master, and enthusiastically exerted themselves to defend and propagate his doctrines. "The economists were in reality, and not merely in appearance, a sect of philosophers.

> Secta fuit servare modum, finemque tueri
> Naturamque sequi, ritamque impendere vero,
> Nec sibi sed toto genitum se credere mundo.

They acted from honest zeal for the truth, and not from fashion, eccentric tastes, or the love of singularity; their sole object was to enlighten and improve mankind; and to them, among political inquirers, belongs the rare praise of having first pointed out the natural order of things, or the observed course of nature in the conduct of the world, as the example and guide of human policy." (s. s.)

RAD

Boundaries and Extent.

RADNORSHIRE, an inland county of South Wales, bounded on the north by Montgomeryshire, on the west by the counties of Cardigan and Brecon, on the south-east by Herefordshire, and on the north-east by Shropshire. Its extremities from east to west are twenty miles, and from north to south twenty-four miles, as under. Its surface is computed to measure 426 square miles, or 272,640 English statute acres.

Population and Rental.

The population in 1811 amounted to 20,900 souls, and in 1821 to 22,503, of whom 11,300 were males, and 11,203 females. The total sum charged to the property-tax in 1811, under the heads of rent of land and tithes, was, for the former, L. 88,250, and for the latter L. 9373. On comparing these numbers with the other returns of Great Britain, it appears that this county is the lowest in numerical population, except the county of Rutland; although its annual rental is higher than either Anglesey or Merioneth.

Jurisdiction and Divisions.

This district of country continued under the jurisdiction of the Lords Marchers, until it obtained the privileges of a county by act of Henry VIII., and was divided into the hundreds of Radnor, Knighton, Painscastle, Rhayder, Colwyn, and Kevenlleece. By the same act it was also empowered to return two members to Parliament, one for the county, and one for the contributary boroughs of Radnor, Rhayder, Knighton, Knuclas, and Kevenlleece. The county is farther divided into parishes and townships. The former are fifty-two in number, and are all in the diocese of St David's, except five, which are included in the English diocese of Hereford. New Radnor, said to have been at one period the principal town

Radnorshire. is now a very poor village; it was an ancient borough by prescription, and has also had charters granted by Queen Elizabeth, and by George II.

Face of the Country. Two-thirds of the whole area of the county are supposed to be uninclosed, and uncultivated. An extensive mountainous tract, nearly in the centre, is usually called the Forest, though there is no reason to believe it was ever covered with trees. A part of this range still belongs to the Crown, although the forests of Radnor and Blathvagh have both been alienated, and are now held by Thomas Frankland Lewis, Esq. and Richard Price, Esq. as foresters. There is nothing remarkable in the circumstances or character of these mountains; the summit of which was ascertained, by Colonel Mudge, to be 2163 feet above the level of the sea. Within their limits is a torrent, called by a name, which, when translated, is "Water-break-its neck," that falls abruptly from a height of about 150 feet. The higher ranges produce only heath, but the sides and lower parts of the hills, which are less exposed to the winds, are entirely devoted to the pasturage of sheep and small horses. The north-western angle of the county is mountainous and uninclosed, and it was in the recesses of these wilds that the British monarch, Vortigern, retreated from the Saxons. On the eastern and southern districts, the valleys are wider and more fertile, and abound with small rivulets: the hills are less elevated, and are partially clothed with wood.

Soil and Climate. The soil of this county is as varied in quality as its position is in elevation. A small portion of the southern angle is composed of the fertile red earth, which prevails in the adjoining counties of Brecon and Hereford. The mountains on the western side are chiefly of the primary slate rocks which abound in Wales; and the valleys between these and the forest have frequently a clayey substratum retentive of water. The forest, and the other subordinate hills connected with it, consist of a slatey rock, containing a portion of lime, which decomposes rapidly on exposure to the atmosphere. The valleys to the eastward of this range are chiefly of a fertile loamy soil, incumbent on an extremely absorbent gravel. The climate is wet and stormy, and the spring months are particularly cold and ungenial. It is, nevertheless, healthy: there are no peculiar or prevalent diseases, and the inhabitants are robust and long lived.

Rivers and Lakes. The principal river is the Wye, which enters the county at Savan y Coed, and flows to the south till it divides it from Brecon. Its tributary streams are the Elan, the Ithon, the Edda, and the Mackwy. The river Terne flows on the eastern border, and continues its course by Ludlow to the Severn. The Lug and the Arrow, in the more central parts, form considerable streams before they enter the county of Hereford. There are some small lakes or pools requiring notice only as contributing to the beauty of the scenery. These are—Llyn, Llanbychllyn, Hendwell Pool, and Llyn-Gwyn. A cataract, at Rhayader, was formerly an object much visited by travellers; but the construction of a bridge has widened the channel, and deprived it of much of its remarkable character.

Agriculture. The agriculture of the county is gradually improving. Irrigation has long been practised to a considerable extent, and its effects on absorbent soils are found to be highly beneficial; but the process is not conducted in the most scientific manner. Lime is abundantly used as a manure, and is chiefly supplied from a valuable stratum of rock near Old Radnor. The ploughing was usually performed by two oxen and two horses; but oxen are now seldom used, and the plough with two horses is in gradual adoption. The implements of husbandry are, for the most part, in a rude form. Most of the farms consist of an equal portion of arable and of grass land. The latter is generally appropriated to the dairy, and the young cattle are reared on the more hilly and barren spots. About one-fifth of the county is under the plough, and one-tenth meadow: the remainder is generally used for sheep walks.

Cattle. In the mountainous districts the cattle differ little from those which are common in the principality of Wales, but in the more fertile parts the Herefordshire breed prevails. The sheep are small, and when fattened, their mutton is excellent: the horses also are generally small, strong, and hardy.

Commerce, Manufactures, and Minerals. There is little commerce carried on in this county, and the only manufactures are of flannels and coarse woollen cloths, which the inhabitants make for their own use. Cattle, sheep, horses, wool, butter, and, from the south-east districts, a surplus of grain, are sent annually to the markets of England. The county is not known to contain any valuable minerals. A lead mine has been opened and abandoned, and, in some places, an uncertain belief has prevailed of the existence of copper. Various mineral springs are known, and Llandrindad is a place of resort on account of the medicinal qualities of its saline sulphureous, and chalybeate wells. In several other parts are similar springs, the properties of which have not been accurately ascertained.

Antiquities. There are many vestiges of antiquity. The Abbey of Cwm Hir stood formerly in a singularly retired and romantic situation on the banks of a rivulet, which runs into the Wye. A small vestige remains of a castle at New Radnor, which was assailed and destroyed "by the irregular and wild Glendower," previous to the battle noticed by Shakespeare, in the first part of Henry IV., when Mortimer was taken prisoner. It was fought at Pilleth in this county. A Roman road, which reached from Chester to Caermarthen, traversed this county, entering its confines on the northern extremity, in the direction of Newtown, following the valley of the river Ithon, and crossing the Wye into Brecknockshire, near the town of Beulth. At Cwm, near Llandrindad, the remains of a Roman station, on this road, are still discernible.

The market towns, and their present population, are as follows: Presteign, 1387; Knighton, 1000; Rhayder, 647. The principal gentlemen's seats are—Slanage Park, Edward Rogers, Esq.; Maeslowgh, Walter Wilkins, Esq.; Harpton Court, T. Frankland Lewis, Esq.; Wellfield, D. Thomas, Esq.; Downton, Percival Lewis, Esq.; Pennybout Hall, J. C. Severn, Esq.; Cwm-Ellan, R. Peel, Esq.; and Noyadd, H. Powell Evans, Esq.

See Rees' *South Wales*, Malkin's *South Wales*, Clark's *Agriculture of Radnorshire*, Barber's *Tour through South Wales*. (W. W.)

Railway.

RAILWAY, a species of road or carriage-way, in which the track of the carriage-wheels being laid with bars, or rails, of wood, stone, or metal, the carriage is more easily drawn along this smooth surface than over an ordinary road.

Wooden Railways.

Wooden railways are said to have been introduced at the Newcastle coal-mines so early as the year 1680, for transporting the coals from the mouth of the pits to the ships in the river Tyne. Even at that period, many of these mines employed each of them 400 or 500 carts in this traffic; it became, therefore, an object of manifest importance to reduce the great expence thereby incurred in the keeping up of horses, drivers, and roads; and the plan of wooden rails was the best, and, indeed, the only effectual method which could at that time have been devised for the purpose; for which also the situation was in other respects favourable, presenting in most cases an easy descent towards the river. These railways then were very generally introduced, and continued for a long period in use in this part of the kingdom. Slips of ground of the requisite breadth for the railway were marked out between the coal-pits and the river, and were either leased by the coal owners, or purchased of the different proprietors whose ground the proposed line of road intersected in its course. To obtain the most easy and regular descent, this line was varied in its direction to meet the inequalities of the ground; or, where these inequalities were inconsiderable, it was carried straight forward, and the regular slope made up by embankments and cutting. The ground being then smoothed and levelled as for an ordinary road, large logs of wood, termed *sleepers*, cut in lengths equal to the breadth of the road, were laid across it, and firmly bedded into it at short distances, to sustain and hold fast the rails, or slips of wood, on which the waggon-wheels were intended to run. These rails were made of beech, and were laid end to end, so as to form two continued lines of rail or wooden ridges, running parallel to each other, along each side of the road, crossing the large logs at each of their extremities, on which they rested as on so many foundations; and were also nailed, or otherwise secured, to keep each piece in its proper place. The waggons were of the usual construction, but of a large size, so as to contain several tons of coals, and set upon low wheels; the smoothness of the way rendering wheels of the ordinary size unnecessary. On these rails a single horse could readily draw three tons of coals from the pits to the river. Where any steep declivity occurred on the road, this was termed a *run*, or an inclined plane; and on it the descent of the waggons was retarded, and regulated by a species of brake, or crooked lever, termed a *convoy*, attached to the waggon and managed by the driver. The banks of the Tyne, near Newcastle, are remarkably steep on each side; but instead of forming inclined planes on them, the railway was here continued on a wooden stage, raised to the same height as the top bank of the river, and carried forward until it came perpendicularly over the river side, where a wooden platform, termed a *staith*, was erected for the convenience of delivering the coals; the waggons being emptied into a trough, or spout, down which the coals descended either directly into the ships, or into the store below.

Iron Railways.

Such was the construction of the original railways, in which we evidently perceive all the parts and members of the railway as it is formed at the present day; viz. the regular formed road, the rails, the sleepers, the low waggons, and the inclined plane. Their only defect consisted in the soft and decaying nature of the wood, the wear and tear of which caused such expence for repairs, as greatly limited their application; so that it was only the shortness of the distance, and the great extent of the traffic, which rendered their application at all beneficial. It was only about the year 1738 that they were attempted in the collieries of Whitehaven; and it does not appear that they were adopted in any other part of the kingdom. The use of iron, therefore, in place of wood, was an essential improvement in the construction of railways, and caused, indeed, a complete change in this, as it has done in every other branch of practical mechanics into which it has been introduced. Flat bars of iron were at first fastened on the top of the wooden rails; but after various unsuccessful attempts, the rails themselves were at last wholly composed of iron, cast in short bars, united at their extremities, and resting on sleepers, or square blocks of stone, disposed at short distances along each side of the road; and this construction having been once fairly reduced to practice, was not only adopted universally in place of wood, but soon led to new and more extensive applications. Iron railways were quickly introduced into all the coal and mining districts of the kingdom. They were employed on canals, in place of locks, to raise the barges on an inclined plane from a lower to a higher level; in some instances they were adopted in preference to the canal itself; and, on the whole, they now form an important auxiliary to inland navigation, pushing the channels of trade and intercourse into districts otherwise inaccessible, and even into the interior of the mines.

Railways in England and Wales.

The railways in Britain are so numerous, that it would exceed our limits to specify the particular lines. In the Newcastle coal district, on the river Wear, in the coal and mining districts of Yorkshire and Lancashire, as well as of Derbyshire and Staffordshire, there are numerous railways branching off from the navigable rivers and canals to the different mines. In Shropshire also, and in the great mining districts along the vale of the Severn, the use of railways is very general, and it was here that the inclined plane was first brought in aid of inland navigation. In Surrey, there is a railway of a considerable extent, termed the Surrey Railway, and this presents one of the few attempts that have been made to form public railways for general use. In the great mining districts on the west of the Severn, including South Wales, the rail or tram roads are very numerous; and here, owing to the steepness and impracticable nature of the ground, they have been of essential utility in supplying the place of canals. In the year 1791, there was scarcely a single railway in all South Wales, and in 1811, the completed railroads connected with canals, collieries, iron, and copper-works in the counties of Monmouth, Glamorgan, and Caer-

Railway.

marthen, amounted to nearly 150 miles in length, exclusive of a great extent within the mines themselves; of which one company in Merthyr-Tydvil possessed 30 miles under ground. In Monmouthshire, the Sirhoway railway forms one of the first in point of magnitude which has hitherto been constructed. It extends from Pilgwelly, near Newport, to the Sirhoway and Tredagar iron-works, distant 23 miles, whence it is continued five miles farther to the Trevil lime-works, in Brecknockshire, along with a branch to the west, to the Rumney and Union Iron-works. This railway was made by the Monmouthshire Canal Company, under the authority of an act of Parliament. From Sirhoway, a branch proceeds eastwards to the Ebbwy works, and from thence down the course of the Ebbwy to Crumlin Bridge, whence it joins the canal from Newport; and from Sirhoway again, the Brinare railway is continued over the Black Mountain to the vale of the Uske at Brecon, and from thence to Hay on the river Wye. In Glamorganshire, the principal railways are the Cardiff and Merthyr-Tydvil, the Aberdare, and the Swansea railways. In Caermarthenshire, the principal railway is that which extends from Caermarthen to the lime-works near Llandebie, a distance of 15 miles.

From this account of the chief railways in England and Wales, it will appear that this species of inland carriage is principally applicable where trade is considerable and the length of conveyance short; and is chiefly useful, therefore, in transporting the mineral produce of the kingdom from the mines to the nearest land or water communication, whether sea, river, or canal. Attempts have been made to bring it into more general use, but without success; and it is only in particular circumstances that navigation, with the aid either of locks or inclined planes to surmount the elevations, will not present a more convenient medium for an extended trade. South Wales, however, presents an example, where the trade being great, and also chiefly descending, the country rugged, and the supply of water scanty, railways have been adopted with complete success; and have been found in some cases at least equal to canals in point of economy and dispatch. The Surrey railway, not having these advantages, has scarcely answered the expectations of its projectors, more especially the southern line from Croydon to Gadstone. It was at one time proposed to continue this railway to Portsmouth, but the plan was abandoned.

Railways in Scotland.

In Scotland there are various railways proceeding from the different mines throughout the kingdom. The principal one in point of magnitude is the Duke of Portland's railway, extending from the town of Kilmarnock to the harbour of Troon, a distance of nearly ten miles. Its chief object is the export of coal and lime, in which articles a great trade is carried on by means of the railway. In the coal and mining districts round Glasgow, there are numerous smaller railways, and also in the coal fields of Mid Lothian and Fife. Plans have been proposed for a public railway from Edinburgh to the different coal-works in the neighbourhood. An extensive railway was also at one time projected from Glasgow to Berwick-upon-Tweed, but none of those schemes have been carried into effect.

Construction of Railways.

The original wooden railways already mentioned are the model on which all the succeeding ones have been formed, and of which we shall now describe shortly the construction. In regard to the road itself, this should, in the first place, be formed in such a direction, and with such a declivity as may best suit the nature of the ground through which it passes, and of the trade to be carried on upon it. If the trade, for example, be all or chiefly in one direction, the road should obviously decline that way, so that the waggons, with their contents, may descend on this inclined plane as much as possible by their own gravity. The inclination should also be proportioned to the extent of the trade up the railway, so that the draught each way may be equal. If the exports and imports, therefore, be equal, the road should be on a level; and where the ground will not permit that declivity or level best suited to the trade, the line should be varied, and the inequalities made up, if it can be done at a moderate expence, so as to bring it as near as possible to the proper standard. If the inequalities are such as to render this impracticable, the only resource lies in inclined planes. Where the difference of level, for example, between the two extremities of the road is such as would render an equal declivity too steep, the road must then be carried, either on a level or with the due degree of slope, as far as practicable, and then lowered by an inclined plane; on which the waggons are let gently down by means of a brake, are dragged up by means of an additional power to that which draws them along the road, or at once let down and drawn up by means of a roller or pulley, the heavier preponderating over the lighter. In laying out a line of railway, therefore, as every situation presents peculiar circumstances, no general rule can be laid down, and the plan must be left to the skill and judgment of the engineer.

The line of railway being fixed on, the road is then properly formed, and of such a width as will be sufficient for containing the opposite rails, and for forming a foot-path on one side. The distance between the opposite rails varies from three feet to four and one half feet; some preferring a long and narrow waggon, and others a broad short one. Hence a breadth of from nine to twelve feet will be sufficient for a single road, and from fifteen to twenty for a double one. The next operation is the setting and firm bedding of the stone sleepers. These consist of solid blocks of stone, each of the weight of one or two cwt. Their shape is immaterial, provided their base be broad, and their upper surface present an even and solid basis for the rail. They are placed along each side of the road, about three feet distant from each other from centre to centre; the opposite ones being separated by the width between the opposite rails. The ground under them is beat down to form a firm foundation, or, if it be of a soft nature, is first laid with a coat of gravel or small metal, and this beaten under the stones; the situation of each stone being properly gauged both as to its distance from the adjoining ones, and as to the level or declivity of its upper surface, on which the rails are in-

tended to rest. The space between the sleepers is then filled up with gravel, metal, or other road materials, such as may consolidate into a hard and firm mass.

The next object is the construction of the iron rails; and on this point two very different plans have been adopted, each of which has its advocates, and is practised to a great extent. The one is termed the *flat rail*, or tram plate; the rails being laid on their side, and the waggon-wheels travelling over their broad and flat surface. The other is termed the *edge rail;* the rails being laid edgeways, and the wheels rolling on their upper surfaces. The flat rail, or tram plate, consists of a plate of cast-iron, about three feet long, from three to five inches broad, and from half an inch to an inch thick; extending from sleeper to sleeper, and having a flaunche turn up or crest on the inside, from two and a half to four inches high. This rail bears on the sleepers at each end at least three inches, where the rails are cast about half an inch thicker than in the middle. As there is no intermediate bearing for the rail between the sleepers, except the surface of the road, the use of the flaunche is not merely to prevent the waggon from being drawn off the road; it resists the transverse strain arising from the weight of the waggon; on this account it is often, and with great propriety, raised higher in the middle than at the sides, forming an arch of a circle; and, to strengthen the rail still farther, a similar flaunche, arched inversely, is added below, as represented in Plate CXV. figs. 1, 2, 3. The weight of each rail is from forty to fifty pounds. To unite these rails into one continued line, they are merely laid to each other, end to end, all along each side of the road; being kept in their places, and at the same time made fast to the sleepers, by an iron spike driven through the extremity of each rail into a plug of oak fitted into a hole in the centre of each sleeper. This spike is about six inches long; it has no head, but the upper end of it forms an oblong square, about one inch broad, half an inch thick; and the hole in the rails, through which it passes, is formed by a rectangular notch, half an inch square, in the middle of the extremity of each rail; the opposite notches of each rail forming, when laid together, the complete oblong square of one inch by half an inch, and slightly dovetailed from top to bottom, so as to fit exactly the tapering head of the spike, which is driven clear below the upper surface of the rail. Plate CXV. fig. 4, represents a section of a rail, with its sleeper and fastening. Wherever the rails cross any road, the space between them and on each side must be paved or causewayed to the level of the top of the flaunches, that the carriages on the road may be enabled to pass clear over the rails. In single railways it is necessary to have places at certain intervals where the empty waggons, in returning, may get off the road to allow the loaded ones to pass. A place of this kind is termed a *turn-out;* and the waggons are directed into it by a moveable rail termed a *pointer*, fixed at the intersection between the principal rail and the turn-out, and turning on its extremity, so as to open the way into the turn-out, and shut that along the road. This contrivance is also used whenever one line of railway crosses another. It is represented at Plate CXV. fig. 5, where, also, fig. 6 is a plan of the railway and of the turn-out.

The tram roads have been universally adopted in Wales, where they are preferred to any other species. They are also used in most parts of England. The Surrey railway is of this description, and was designed by Mr Jessop. In Scotland the Duke of Portland's railway, which, we believe, was planned by the same engineer, is of the same kind, and the rails nearly of the same dimensions. These flat railways have one advantage, in admitting waggons or carts of the ordinary construction, and this is particularly exemplified in the Troon railway. According to an account with which we have been favoured by Mr Wilson of Troon, " there are several kinds of waggons used upon the railway under certain restrictions; such as four-wheeled waggons with flat bottom and low shelmets for carrying stone, limestone, grain, timber, slates, &c. from the harbour to Kilmarnock, the mills," &c. " The common make of a cart is allowed to use the railway if the wheels are cylindrical, and there be no greater load on each pair than 28 cwt. A great deal is done with these carts in carrying timber, barks, grain, &c., as, with the same cart, they can carry these articles into and through the streets of the town."

The other railways in Scotland, however, are chiefly of the edge kind. In the principal collieries of the north of England, also, the flat rail has been almost entirely superseded by the edge rails, and the latter are now generally admitted to be decidedly superior in the ease of draught which they occasion; the edge of the bar presenting less friction, and being less liable to clog up with dust and mud, or to be obstructed with stones driven off the road upon the surface of the rails. The edge rail consists merely of a rectangular bar of cast-iron, three feet long, three or four inches broad, and from one-half inch to one inch thick; set in its edge between sleeper and sleeper, and bearing on the sleepers at its extremities. The upper side of the rail is flaunched out to present a broader bearing surface for the wheels, and the under side is also cast thicker than the middle, for the sake of strength. But the greatest strength is evidently attained by casting the rail not rectangular, but deeper in the middle than at the ends, to resist better the transverse strain. The ends may be safely reduced nearly to one-third of the depth in the middle, and still be equally strong. To unite the rails together, and at the same time preserve them in their places, and in their upright position, and to bind them also to the sleepers, they are set in a cast-iron socket or chair, which is attached firmly to the sleeper. This socket embracing the extremities of the adjacent rails, which are here made to overlap a little; a pin is driven at once through the rails and through the socket, and binds the whole together. This is the general method of uniting the edge rails, but the shape and dimensions of the metal chair and of the overlap of the rails are varied according to the judgment and taste of the engineer. Plate CXV. fig. 7, represents a section of an edge railway with the sleepers and waggons, &c.;

Railway.

and figs. 8, 9, 10, is an enlarged section of a rail and sleepers with a plan. Since edge railways have come into more general use, an essential improvement has been made in their construction by the use of malleable iron, in place of cast-iron, in forming the rails. The advantage of malleable iron rails is, that they are less subject to breakage than cast-iron; a circumstance of importance in this case, where it is not easy to avoid those jolts and sudden shocks which cast-iron is least of all capable of withstanding, and though they should happen to give way, they are easily repaired. They can also be laid in greater lengths, and requiring therefore fewer joints; they can be bent with ease to the curvature of the road; when worn out they are of greater value; and lastly, their first cost is very little, if at all, greater than that of cast-iron rails. Malleable iron is, no doubt, less able to withstand exposure, decaying more readily under the influence of air and moisture; but hitherto this inconvenience has not been felt, and, on the whole, the malleable iron is now decidedly preferred. These rails are laid and joined in the same manner as the cast-iron, only in greater lengths. Malleable iron, we believe, was first introduced in railways by Mr George Grieve, at Sir John Hope's collieries, near Edinburgh, where it was first tried on the lighter work which is done under ground. The rails consisted of square bars one inch or one and one-fourth inch square, nine feet long, resting on one or two sleepers in the middle, and resting and made fast to sleepers at the extremities; a simple knee being formed on each end of the bar, and the two knees of each two adjacent rails jammed into one socket in the sleeper. The use of these rails was found so beneficial, that they have since entirely superseded the flat cast-iron rail in general use at the time of their invention. For heavier loads the rails are made deeper. We have been favoured with the following account of their construction by an engineer (Mr Neilson of Glasgow) who has formed several of the kind.

"One of them is on the property of the Earl of Glasgow, commencing at the Hurlet extensive coal and lime-works, and extending to the Paisley canal, a distance of about two miles. It is formed of flat bar iron two and one-fourth inches deep, by nearly three-fourths of an inch thick, and the rail in lengths of nine feet, each rail being supported at every three feet by a sleeper and cast-iron chair. The joinings are formed by a cast-iron dovetailed socket suited to receive the jointed ends of the bar, and a dovetailed glut or key, by which means the several rails are joined as if into one continued bar."

An improvement has lately been made in the construction of malleable iron rails, which promises to be of essential utility. It consists in the use of bars, not rectangular, but of a wedge form, or swelled out on the upper edge. In the rectangular bar there is evidently a waste of metal on the under surface, which, not requiring to be of the same thickness as where the waggon-wheel is to roll, may be evidently reduced with advantage, if it can be done easily. The bar may then be made deeper, and broader at the top than before, so as with the same quantity of metal to be equally strong, and present a much broader bearing surface for the wheel. This has been accomplished by Mr Birkinshaw of the Bedlington Iron-works, who has obtained a patent for these broad topped rails. The peculiar shape is given them in the rolling of the metal, by means of grooves cut in the rollers, corresponding with the requisite breadth, and depth, and curvature of the proposed rail. Mr B. recommends his rails to be of 18 feet in length. We have seen one of these patent rails at Sir John Hope's colliery; and it certainly forms the most perfect iron rail which has hitherto been contrived; combining very simply and ingeniously in its form the qualities of lightness, strength, and durability. It is twelve feet long, two inches broad along the top, about half an inch along the bottom, and still thinner between. It rests on sleepers at every three feet, and at those places the rail is two inches deep, while in the middle point between the sleepers it is three inches deep. Fig. 11 is a longitudinal section of this rail, and figs. 12 and 13 are transverse sections at the sleepers, and at the middle point between each sleeper. All these inequalities, we believe, are produced on the metal by means of the rollers; and this circumstance is well deserving of attention, as it may obviously be applied not merely to the formation of railways, but to a variety of other purposes in the arts. The moulding and shaping of the metal in this manner is quite a new attempt in the iron manufacture, and it is not easy to say how far such an invention may yet be carried by the skill of British artists.

Waggons used on Railways.

The waggons used on railways are of various sizes, but of nearly the same general shape, and all set on four wheels from two to three feet diameter. They are made to carry from 20 to 50 cwt. exclusive of the waggon itself, which weighs from 12 to 15 cwt. The axles of the fore and hind wheels are fixed three feet asunder or more, so that the rail is never loaded with more than one-fourth of the waggon at once. According to Mr Wilson, "The size of the coal waggons of Kilmarnock colliery are, on an average, mean length 80 inches, mean breadth 45 inches, and depth 30 inches. Each contains 40 bushels, equal to 32 cwt. of fine coal, and 35 cwt. of blind or malting coal. The weight of the waggon, exclusive of the coal, is 13 cwt. Each waggon, including two pair of wheels and axles, costs from about L. 13 to L. 15, and are mostly lined with sheet iron." In Sir John Hope's railway the waggons are also nearly of the above dimensions. In the Sirhoway railway each waggon carries two and one-half tons.

Expence of constructing Railways.

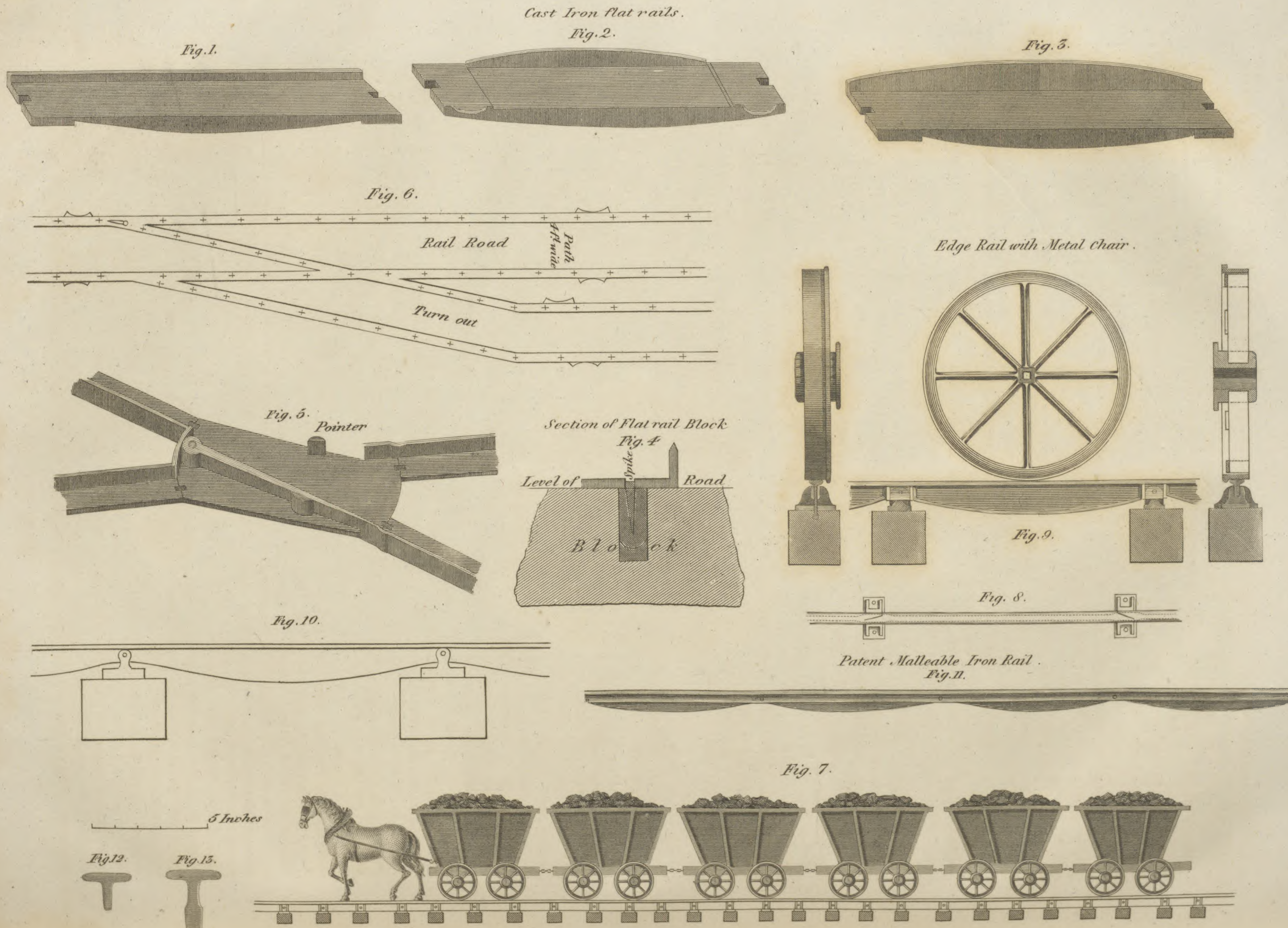
In regard to the expence of constructing a railway, this will depend greatly on the ease or difficulties to be met with in forming the road, and making up the inequalities to the required slope. The above railway described by Mr Neilson cost only L. 660 *per* mile; but where there are considerable embankments to form, bridges to build, and deep cuttings, the expence may rise to L. 4000 and L.5000 *per* mile. The usual rate of tonnage on coals, &c. conveyed on railways is 2d. *per* ton *per* mile.

Comparative ease of Draught.

An important consideration regards the work done, or capable of being performed on a railway. On this point, however, the accounts from different railways are various; the performance depending on

RAILWAY.

PLATE. CXV.



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many circumstances little attended to in the general estimate of work; such as the quality of the horses, the state of the road, the greater or less declivity of the rails, and various other circumstances. More exact observations or experiments are therefore wanting to form correct notions on this subject; but in the mean time, we shall state such facts as have been noticed by different observers. The most exact experiments were made by Joseph Wilkes, Esq. of Measham in Derbyshire. The result is, that one horse, value L.20, on a railway declining at the rate of one foot perpendicular to 115 in the length of the road, "drew 21 carriages or waggons, laden with coals and timber, amounting in the whole to 35 tons, overcoming the *vis inertiæ* repeatedly with great ease." This performance appears, no doubt, enormous; but was evidently owing not so much to the diminution of friction by the railway as to the great declivity; circumstances whose effect must be distinguished in order to obtain any general rule for future works. It is well known that, on any inclined road or plane, every carriage has a tendency to descend of itself, and with a force in proportion to its own weight, exactly as the height of the plane is to its length. In the above example, therefore, the carriages, independent of any external force of traction, would have been urged by their own gravity with a force of 115th of their weight, and equal, therefore, to 680 lbs. But as it will not be too low an estimate to assume 150 lbs. as the working draught of a horse, hence the waggons would descend by their mere weight as if they had been dragged on a level way by at least four horses. If, then, to this 680 lbs. we add 150 for the action of the horse, the sum, or 830 lbs. will be equal to the power necessary to overcome the friction and inertia of these waggons, and which appears by division to amount to $\frac{1}{94}$th of their whole weight; so that, if the railway had been level, the horse would only have drawn $6\frac{1}{4}$th tons. Carriages on an ordinary road require $\frac{1}{12}$th or $\frac{1}{15}$th of their actual weight to draw them along; so that, on a railway, the ease of draught is six times greater than on a common road. The same horse, Mr Wilkes observes, drew up the acclivity five tons with ease. Here the weight of the waggon, or its 115th part, would act against the horse, which would not only have to overcome their friction and inertiæ, but to drag also this additional load upwards. But $\frac{1}{94} + \frac{1}{115}$ of 5 tons $=$ 216 lbs., the force of traction, which was evidently a strained effort. The same horse drew three tons up an acclivity of 1 in 20. Here $\frac{1}{94} + \frac{1}{20}$ of 3 tons, $=$ 407 lbs., a power of traction which few horses could exert, and none could sustain for any length of time. The other experiments of Mr Wilkes agree nearly with the above. Mr Outram, Engineer, observes, that, with a declivity of 1 in 108, the waggons will almost descend of themselves, so that the horse has only to pull a little at his load. This would make the friction and inertia nearly $\frac{1}{100}$th of the weight, and the draught of a horse nearly $6\frac{3}{4}$th tons. Mr Telford observes, that in a railway, with a declivity of 1 in 98, a horse will readily take down waggons containing from 12 to 15 tons, and bring back the same with four tons in them. The total load, in the first case, would be about 18 tons, and in the second 8 tons. Here the waggons being urged with $\frac{1}{98}$th of their weight; this makes the friction and inertia equal to $\frac{1}{70}$th of the weight, and the draught of a horse on a level way only $4\frac{3}{4}$th tons. In the Troon railway, the declivity is about 1 in 660; and, according to Mr Wilson's account, some horses take down two and some three waggons each, containing 33 cwt. of coal, and weighing itself 13 cwt., travelling at the rate of three miles an hour. The total load here may be averaged at 115 cwt.; and, the waggons being used with $\frac{1}{660}$ of their weight, this makes the friction and inertiæ $\frac{1}{75}$th of the weight, very nearly equal to the last. We have been favoured by Mr Grieve with the following particulars regarding Sir John Hope's railway, which is of the edge kind. It is on a level; and one horse draws five loaded waggons, each containing 30 cwt. of coals, and weighing, unloaded, 12 cwt. equal in all to 210 cwt. or $10\frac{1}{2}$ tons; travelling at the rate of four miles an hour, deducting stoppages. This makes the friction 150th of the load. This performance is beyond any that we have yet stated, and shows decidedly the ease of draught of the edge rail. Previous to the formation of this railway, it required eight horses for the work which is now done with one. On the whole, then, it may be concluded, that on a level tram road, making allowance for the weight of the waggon, one horse will be required for every four tons of coals, or other articles conveyed; and on an edge railway, one horse will be required for every seven tons. On an ordinary canal, one horse, with a boat, will be sufficient for every 30 tons. But the first cost of a canal is three or four times greater than that of a railway; so that, in some cases, it may become a question, whether a railway might not be adopted with advantage.

On some of the railways near Newcastle, the waggons are drawn by means of a steam-engine working in a waggon by itself, the wheels of which are driven by the engine, and acting on a rack laid along the railway, impel forward both the engine and the attached waggons: in some cases the wheels of the waggon operate without rail work, by the mere friction between them and the railway. The steam-engines employed for this purpose are of the high pressure kind; these requiring no condensing apparatus. But this application of steam has not yet arrived at such perfection as to have brought it into general use. (R. R. R.)

REFRACTION (DOUBLE). See ADDENDUM to this Volume.

Situation and Boundaries.

RENFREWSHIRE, a county in Scotland, lying between 55° 41′ and 55° 48′ north latitude, and between 4° 15′ and 4° 53′ west longitude; is bounded on the west and north by the Frith of Clyde (excepting that a small tract opposite the town of Renfrew is situated on the north bank of the Clyde), and it has Lanarkshire on the east and Ayrshire on the south. From east to west it extends about 26 miles, and from north to south from nine to 13; and has an area of nearly 241 square miles, or 154,182 English acres. It comprehends 21 parishes, besides a small

Divisions.

Renfrewshire.

portion of some others, the churches of which are situated in the adjoining counties. Two of the parishes, Eaglesham and Cathcart, belong to the presbytery of Glasgow, and the other nineteen compose the presbytery of Paisley. Notwithstanding its moderate extent, its manufactures and commerce render it one of the most important in Scotland.

Surface.

About two-thirds of this district, comprising the western and south-eastern sides, are hilly, the medium elevation being from 500 to 600 feet; Mistylaw, the highest hill, is about 1240 feet, and two others may be about 1000. This division is, in general, kept in pasture, for which it is better adapted, by the nature of its surface, than for tillage; though, as it has a free light soil, which readily absorbs water, it is seldom injured by moisture. The cultivated land lies on the north and north-east, and in the centre of the county, on both sides of the Black Cart. Of this, however, the greater part is not level, but consists of low detached hills, among which there is a good deal of natural wood in the state of coppice, and many winding rivulets, which give variety to the landscape. Much of this tract has a close subsoil of small stones and coarse clay, almost impenetrable to water, though there are here many flat holms of great fertility. It is only between Paisley and the Clyde that the country sinks down to a plain, the extent of which does not exceed 12,000 acres. Here the soil is generally a deep rich loam, of a dark brown colour, sometimes of the nature of what is called *carse clay*; and much of it seems to have been formed by the deposition of vegetable mould from the higher grounds. Moss prevails in the first and last divisions, but is not found in the second or middle one, where the soil is pretty uniform.

Climate.

Like the other western counties of Scotland, Renfrewshire has a moist climate, with frequent rains; and the prevailing wind is from the south-west. At Largs, a village in Ayrshire, near the western extremity of this county, the yearly quantity of rain, in 1809 and 1810, was $38\frac{2}{3}$ inches; at Glasgow, near the eastern extremity, for 30 years, from 1761 to 1790, it was 29·65 inches.

Rivers.

The principal rivers are the Clyde, the White Cart, the Black Cart, and the Gryfe. The first, which only flows along the boundaries of this county, is by far the most considerable and important. The White Cart, which rises in Lanarkshire, enters Renfrewshire from the south; and, flowing west towards Paisley, and then north, receives the united streams of the Black Cart and the Gryfe at Inchinnan, and joins the Clyde about six miles below Glasgow. By means of a short cut, a little above Inchinnan, the White Cart has been rendered navigable from Paisley to the Clyde. The Black Cart from the south-west, and the Gryfe from the west, meet at Walkinshaw, about two miles above their confluence with the White Cart. These streams are chiefly deserving of notice for their being employed in giving motion to the cotton and other mills seated along their course. Several other and smaller ones have been applied in the same manner in various parts of the county; a steady supply of water being secured by means of reservoirs, some of which are of the size and appearance of considerable lakes; or by enlarging the natural lakes themselves, of which there are many. Of these last, Castlesemple loch, in the middle of the southern boundary, from whence the Black Cart takes its rise, extending over about 200 acres, is the most considerable. These streams and lakes abound in the usual kinds of fish; but the salmon fishery on the Clyde, so far as it belongs to this county, is not of great value, seldom affording a rent of more than L. 200 a-year.

Lakes.

Minerals.

The minerals of this county are of great importance, constituting the main source of its manufactures and commerce; but we can only advert to them very generally. Coal, limestone, and sandstone, are wrought at Neilston, one of the parishes of the hilly district; and both coal and lime have been found in the flat district near Renfrew; but it is in the middle division that mines are wrought to the greatest extent. Of coal there are generally about 12 different works carried on; of which the most extensive and valuable are at Polmadie, on the north-east boundary, at Hurlet, three miles south-east from Paisley, and at Quareltown, south-east from the Bridge of Johnston, on the Black Cart, near the centre of the county. The coal at this latter place consists of five contiguous strata; the thickness of the whole, measured at right angles to their surface, is upwards of 50 feet; but as, in some places, the seam forms a considerable angle with the horizon, the thickness of the whole in these places, measured vertically, is about 15 fathoms. In consequence of this great depth, it is wrought in floors or storeys. Limestone abounds in various parts, and is commonly wrought at eight different quarries. Ironstone in beds and balls is very generally diffused throughout this middle division of the county. Considerable quantities of pyrites are found in the stratum of coal at Hurlet and Househill, and manufactured into sulphate of iron or green vitriol. Alum is obtained at Hurlet, from the decomposed schistus, which forms one of the strata of its coal mines. Excellent freestone, lying near the surface, is wrought near Paisley and at other places.

Valuation and Rental.

The valuation of the lands of Renfrewshire is L. 69,172, 1s. Scots; but in 1811 the real rent of the lands was L. 127,068, 15s. 9d. and of the houses, L. 106,238, 7s. 2d. Sterling. In 1795 the land rent was only about L. 67,000, so that it must have nearly doubled in fifteen or sixteen years. The landed property in 1811 was divided into 328 estates; of which 300 were under the valuation of L. 500 Scots, and only six above L. 2000 Scots. Nearly half the valuation belonged to estates held under entail, and by corporations, which were not, therefore, allowed to be brought to market. The number of freeholders entitled to vote in the election of a member for the county was 77; but it appears that more than half this number voted on rights of superiority only, and not as owners of estates. There are about 30 seats of noblemen and gentlemen, besides villas belonging to merchants and tradesmen. The county is well covered with woods and plantations. The

Estates.

Renfrewshire.

copse-woods, which are cut every 30 years, used to bring from L. 25 to L. 30 an acre.

Agriculture.

Renfrewshire does not rank high as an agricultural district. Farms are generally small, seldom exceeding 100 acres on the arable land, and 400 or 500 acres on the hills; and the houses and other accommodations of the farmers are proportionally inferior to those of their brethren in most other parts of the lowlands of Scotland. The average rent *per* English acre, in 1811, would be about 15s., varying from 2s. or 3s. to L. 4 or L. 5; partly owing to situation, but still more to the different degrees of the natural fertility of the soil. Garden grounds let at from L. 8 to L. 10, and, in one instance near Greenock, as high as L. 40 the English acre. The University of Glasgow have right to the tithes of several parishes near that city, for which they receive, in some instances, no more than 4s. *per* Scots acre, and in no case more than 15s. The most common period of leases here, as in other parts of Scotland, is 19 years; but many are now shorter, though, in that case, it is the practice to enter into a new lease, two or three years before the old one expires. About two-thirds of the arable land is almost always in grass, on which the stock chiefly kept is cows, whose milk is made into butter. There are few cheese dairies. The rotation of crops is in many instances objectionable, two or more corn crops being taken successively; clover and rye-grass are sown only for hay; and turnips, even upon the most suitable soils, are in very limited cultivation.

Merino Sheep.

A flock of Merino sheep, consisting of about 1000 or 1200, of the pure Paular breed, was sent into this county in 1810, by Colonel Downie of Paisley, who was then in Spain, some of which are still to be found on the farms of the proprietors. In other respects, the rural economy of Renfrewshire presents nothing particularly worthy of notice.

Manufactures.

It is by its manufactures and commerce that this district has been long distinguished. Among its manufactures are cordage and sail-cloth, ship-building, and sugar-boiling, at Greenock and Port-Glasgow, with a variety of others subordinate to these; but Paisley and its environs have long been the seat of its principal establishments. The linen manufacture, in various forms, was carried on here more than a century ago, and continued to extend till superseded by that of cotton, about the year 1780. This last is now by far the most extensive manufacture in the county; and is conducted in all its various branches, from the spinning of the yarn to the finishing of the finest fancy goods. In 1810, the cotton yarn sold was said to amount to L.630,000; and the capital employed in the buildings and machinery of the mills was estimated at L. 300,000. About 7000 looms were then employed in the weaving of muslins, besides 500 which were wrought by steam, and produced coarse cottons to the value of L. 125,000 yearly. Paisley was long distinguished for its silk manufacture, which is now inconsiderable; and that of thread, though still extensive, is said to be on the decline. Soap-making, tanneries, distilleries, breweries, and founderies, with a great many bleachfields and print-fields, furnish employment to a large portion of the inhabitants.

Towns.

The principal towns are Paisley, Greenock, and Port-Glasgow. (See these Articles in the *Encyclopædia.*) It is at these towns, or rather at the two last, that the foreign and coasting trade of the county, and the principal foreign trade of Scotland, is carried on. Greenock and Port-Glasgow have an extensive trade with America and the West Indies, Ireland, and the west of England; and coastwise, and, by means of the Forth and Clyde Canal, with every part of Scotland. The canal proposed to be carried from Glasgow to Ardrossan, through Paisley and Johnstone, has been executed as far as Johnstone, eleven miles from Glasgow; and passing through several populous parts of Renfrewshire, affords great accommodation to the trade between Paisley and Glasgow. The herring and whale fisheries were once prosecuted to a greater extent than at present, though the former is still considerable; and the merchants of Greenock are extensively engaged in the Newfoundland and Nova Scotia fisheries. As Renfrewshire does not raise enough of grain for its consumption, a good deal of corn is usually imported from Ireland and Canada, as well as coastwise. The other imports are the raw materials of its manufactures, and the commodities required for the consumption of its inhabitants; and its exports, the produce of its manufactures, mines, and fisheries, and of its import trade from America and the West Indies.

Poor.

Notwithstanding the extensive manufactures of this county, the great fluctuation in the wages of labour, and its dense population, which, in 1811, was at the rate of 384 *per* square mile, there are regular assessments for the poor only in two or three parishes. In the rest of the county, the poor are supplied by voluntary contributions, aided by assessments imposed when circumstances require them.

Representation.

The county sends one member to Parliament; and its only royal burgh, Renfrew, a place containing about 1600 inhabitants, joins with Glasgow, Rutherglen, and Dumbarton, in the election of another for the Scottish burghs. Paisley and Greenock, notwithstanding their wealth and population, have no vote. The Sheriff Court is now held at Paisley; yet Renfrew is still considered the county town, where the quarter sessions are held, the head courts, and the meetings of the freeholders for the election of members of Parliament.

Population.

The population in 1754 was only 26,645; in 1801 it amounted to 78,056; in 1811 it was 92,596; to which, if there be added the number of registered seamen, about 5000, and of men serving in the navy, army, and militia at the latter period, it would appear that it had quadrupled within 57 years, a rate of increase unexampled in any other county of Scotland. In 1821 it was 112,175; of which 51,178 were males, and 60,997 were females. The *families* employed in agriculture were 2725; in trade and manufactures, 15,780; in other occupations of various kinds, 5472. The increase of the population from 1811 to 1821 was 19,579.

See the general works quoted under the former Scottish counties, and Wilson's *General View of the Agriculture, &c. of Renfrewshire.* (A.)

*

Rennie.

RENNIE (John, F.R.S.), Mechanist, Architect, and Civil Engineer, was born on the 7th June 1761, at Phantassie, in the parish of Prestonkirk, in the county of East Lothian. His father, a highly respectable farmer, died in 1766, leaving a widow and nine children, of whom John was the youngest. The first rudiments of his education were acquired at the village school; and as it frequently happens, that some trifling circumstance in early life gives a bent to the pursuits, and fixes the destinies, of the future man, so it fared with young Rennie. The school was situated on the opposite side of a brook, over which it was necessary to pass by means of a rustic bridge of stepping-stones; but when the freshes were out, the only alternative of crossing the stream was by means of a boat, which was kept at the workshop of Mr Andrew Meikle, an ingenious mechanic, well known in Scotland as the inventor of the threshing-machine, and many improvements in agricultural implements. In passing through this workshop, which stood on his family property, young Rennie's attention was forcibly drawn to the various operations that were in progress; and a great part of his leisure and holiday-time was passed therein. The sons of Mr Meikle, and the workmen, seeing the delight which he appeared to take in examining their labours, were in the habit of indulging him with their tools, and showing him their various uses. His evenings were chiefly employed in imitating those models which had particularly attracted his attention in the workshop; and it is known in the family, that, at little more than ten years of age, he had constructed the model of a windmill, a pile-engine, and a steam-engine. That of the pile-engine is still in existence, and is said to be remarkably well made.

Having continued at Preston school till twelve years of age, he had a quarrel about that time with his schoolmaster, whom he deemed incompetent to give him further instruction, and therefore entreated that he might be permitted to leave the school. But his active mind became restless; for the first time he felt the hours hang heavily on his hands; and having expressed a wish to be placed under his friend Mr Meikle, he employed himself with this ingenious mechanic for about two years: but his mind expanding with his growth, he began to feel that the progress of his intellectual faculties was likely to be retarded by a constant application to manual labour. He therefore at length determined to place himself under the tuition of Mr Gibson, an able teacher of mathematics at Dunbar; where he soon distinguished himself in so particular a manner, that Mr David Loch, General Inspector of the Fisheries in Scotland, in describing a visit which he paid to the school at Dunbar in 1778, notices the great proficiency displayed by young Rennie; prophesying that at no distant period he would prove an honour to his country.* From this school, in less than two years, he returned to Mr Meikle, with a mind well stored with every branch of mathematical and physical science which Mr Gibson could teach him. About this time, Mr Gibson being appointed master to the public academy of Perth, he earnestly recommended young Rennie to succeed him at Dunbar. But his views were of a more aspiring cast. As a matter of favour, he undertook the management of the school for about six weeks, when he returned to his family, occasionally visiting and assisting his friend Mr Meikle, but mostly improving himself in drawing and making models of machinery. His first essay in practical mechanics was the repairing of a corn-mill in his native village; and he erected two or three others, before he was eighteen years of age.

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Resolved, however, that these mechanical occupations should not interfere with his studies, he laid his plans so that he should be able to proceed occasionally to Edinburgh, with a view of improving himself in physical science. He there attended the lectures of Professors Robison and Black, and formed that acquaintance with the former of these gentlemen, which was gradually raised into friendship, and which, perhaps, may be said to have laid the foundation of his future fortune; for by him he was introduced to Messrs Bolton and Watt of Soho near Birmingham. With these gentlemen he remained but a few months, for the purpose of receiving explanations respecting the plan of the Albion Mills, then erecting, the machinery of which he superintended. This exactly suited his views, for, conscious of his own powers, he deemed the Capital the proper theatre to try their strength, and in this he was not mistaken.

In proceeding from Edinburgh to Soho, he had taken the route by Carlisle, Lancaster, Liverpool, and Manchester, for the purpose of visiting the different mills and public works in those great commercial and manufacturing towns; and the remarks which he made on the bridge then building over the Lune at Lancaster, on the docks at Liverpool, and more particularly on the Bridgewater canal, are distinguished by great sagacity, and were of essential use to him afterwards. On leaving Soho, he again made a tour through the manufacturing districts of Leeds, Sheffield, Rotherham, and Newcastle.

For some time after he was settled in London, the Albion Mills, of which Bolton and Watt and Mr Wyatt were the projectors and leading proprietors, and who engaged him to superintend the execution of the mill-work, occupied a great share of his attention. Mr Watt, in his *Notes* to Professor Robison's *Account of the Steam-Engine*, says, That, "in the construction of the mill-work and machinery, they derived most valuable assistance from that able mechanician and engineer Mr John Rennie, then just entering into

* Loch's *Essays on the Trade, Commerce, Manufactures, and Fisheries of Scotland*, Vol. III. p. 211.

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business, who assisted in placing them, and under whose direction they were executed." He also says, that the machinery, which used to be made of wood, was here made of cast-iron, in improved forms, and thinks that this was the commencement of that system of mill-work which has proved so beneficial to this country. In fact, Rennie's mills are the most perfect species of mechanism in that way that exist, distinguished by a precision of movement, and a harmony and proportion of parts that now serve as models throughout the empire. His water-mills are so accurately calculated, that every particle of water is effectively employed, and none of it lost, as in the common mode of constructing water-wheels. There is reason to believe that the difficulties which occurred at the Albion Mills with regard to the ebb and flow of the tides, and which required all the ingenuity of that extraordinary genius Mr Watt, first led Mr Rennie to the study of that branch of civil engineering connected with hydraulics and hydrodynamics, and in which he soon became so celebrated, as to have no rival after the death of Smeaton, in whose steps, he always used to say, he was proud to follow.

Our limited space will not permit us to enter upon even an enumeration of all his great works, much less to give any detailed account of them; we must therefore content ourselves by mentioning some of the most important designs and undertakings in his threefold capacity of mechanist, architect, and civil engineer; three branches of art so intimately blended, as scarcely to admit of a separation.

First, as a Mechanist.—Immediately after the completion of the Albion Mills, in 1786 or 1787, Mr Rennie's reputation was so firmly established in every thing connected with mill-work, that he found himself in a very extensive line of business. To him the planters of Jamaica and of the other West India islands applied for their sugar-mills, which he constructed in a manner so superior to the old ones, that he soon obtained almost a monopoly of these expensive works. The powder-mill at Tunbridge, the great flour-mill at Wandsworth, several saw-mills, the machinery for various breweries and distilleries, were mostly of his manufacture; and wherever his machinery was required to be impelled by steam, the incomparable engines of his friends Messrs Bolton and Watt supplied the moving power; but, contrary to what has been stated in some of the public journals, he never had the least concern in directing, contriving, or advising any one part or movement of the steam-engine. He also constructed those beautiful specimens of machinery, the rolling and triturating mills at the Mint on Tower-Hill, to which Bolton and Watt's engines give motion; and, at the time of his death, he was engaged in the construction of a rolling-mill, and similar machinery, for the intended mint at Calcutta.

As a bold and ingenious piece of mechanism, which may be considered as distinct from positive architecture, there is nothing in Europe that can bear a comparison with the Southwark Bridge. The three immense arches, the centre one of 240, and each side arch of 210 feet span, consist entirely of masses of cast-iron, of various forms and dimensions, put together, on the same principle as a similar fabric of hewn stone; a method of employing iron, which may be considered to form a new epoch in the history of bridge building. Various sinister predictions were entertained against this light and beautiful bridge, which was to be rent in pieces by the expansive power of the first summer's heat, or, if it escaped that, by the contraction of the first winter's cold; but it has stood the test of many winters and summers, and appears not to feel either. Mr Rennie was applied to by the East India Company for the design of a cast-iron bridge to be thrown over the river Goomty at Lucknow, at the desire of the Nabob Vizier of Oude. It consisted of three arches of cast-iron, the centre arch ninety, and each of the other arches eighty feet span. The arches were cast, and a superintending engineer sent out with them, but on their arrival the Nabob, in one of those moments of caprice to which eastern despots, even in their impotency, are so liable, changed his mind, and would not allow it to be put up.

Secondly, as an Architect.—As there are few parts of civil engineering that do not occasionally require the aid of architecture, Rennie, at a very early stage of his progress, was called upon for a display of his skill in this line. Among his first undertakings in either line was that of the Lancaster Canal, which presented many difficulties, and, among others, that of carrying it by an aqueduct over the Lune, so as not to interrupt the navigation of the river. Being one of the largest fabrics of its kind in Europe, and of a pleasing design, it is an object that arrests the attention of strangers, and is very generally admired. The bridges of Leeds, Musselburgh, Kelso, Newton-Stewart, Boston, New Galloway, and a multitude of others, attest the architectural skill, the solidity, and, we may add, the good taste of Rennie; whilst a thousand smaller ones, with the various locks, wharf-walls, quays, embankments appertaining to canals, rivers, and harbours in every part of the United Kingdom, are so many proofs of his diversified talent, and his skill in adapting the means to the end. The Breakwater in Plymouth Sound can scarcely be called an architectural work, but it is constructed on true hydrodynamic principles, and so gigantic in its dimensions, and cyclopean in its structure, as equally to defy the force of the waves and the ravages of time. To Mr Whidby, who has zealously superintended the execution of this immortal work, now near its completion, the highest praise is also due; nor was the plan finally determined on without his advice and assistance.

But the architectural work which, above all others, will immortalize the name of Rennie, is the Waterloo Bridge, a structure which even foreigners admit has no parallel in Europe (and if not in Europe, certainly not in the whole world) for its magnitude, its beauty, and its solidity. That a fabric of this immensity, presenting a straight horizontal line, stretching over nine large arches, should not have altered more than a few inches, not five, in any one part, from that straight line, is an instance of firmness and

solidity utterly unknown, and almost incredible;* but all Rennie's works have been constructed for posterity; he made nothing slight; nor would he engage in any undertaking where, from an ill-judging economy, a sufficiency of funds was not forthcoming to meet his views.

Another work, from a design of his, is now likely to be carried into execution, to which for some years past he had given his attention. It is that of a new stone bridge over the Thames, to replace that disgrace to the present age, the existing London Bridge. His design, which has been selected by a Committee of the House of Commons out of at least thirty that were offered, consists of a granite bridge of five arches, the centre one of 150 feet span, which will be the largest stone arch in the world constructed in modern times. The execution of this work will form a remarkable feature in the future history of the capital, for, of the five bridges which bestride the Thames within the precincts of London, three of them, and those beyond comparison the most magnificent, will have been built from the designs of one man;—a record which will throw a lustre on the name of Rennie, and be read with a feeling of pride by every, even the most distant, branch of the family.

Thirdly, as a Civil Engineer.—The first great attempt in this line of his profession was the survey and execution of the Crinan Canal, a work remarkable for the multitude of practical difficulties that occurred throughout the whole of this bold undertaking; it being necessary in many places to cut down through solid rock, to the depth of sixty feet; and it is rather remarkable, that the second undertaking, the Lancaster Canal, was also replete with difficulties, and called for the exercise of his skill as an architect, as we have seen in noticing the aqueduct over the Lune. But these two works established his reputation as a civil engineer, and his opinion and assistance were required from all quarters. His faculties were now called into full play, and they expanded with the demands made upon them. The rage for canals had pervaded every part of the kingdom, and scarcely any of these useful means of conveyance and communication was thought of without a previous consultation with Rennie; so that in a few years the surveys he was called upon to make were so numerous, that he knew the surface of England as it were by heart, and could tell at once, when a canal was projected, whereabouts the line of it ought to be carried. The following are some of the most important of those whose execution he personally attended: Aberdeen, Brechin, Grand Western, Kennet and Avon, Portsmouth, Birmingham, Worcester, besides many others.

But the resources of his mind were displayed in all their vigour in the plans and construction of those magnificent docks, which are at once an ornament to the capital, and of the utmost utility to commerce and navigation. Nor are these splendid and useful works confined to the metropolis. The docks at Hull, Greenock, Leith, Liverpool, and Dublin, attest his skill; and the harbours of Queensferry, Berwick, Howth, Holyhead, Dunleary (now called Kingstown Harbour), Newhaven, and several others, owe their security and convenience to his labours.

But even those works, splendid as they are, must yield to what he has planned and executed in his Majesty's dock-yards at Portsmouth, Plymouth, Chatham, and Sheerness. The latter was a mere quicksand of forty feet deep, mixed with mud and the wrecks of old ships; the whole of which was excavated, and a magnificent basin constructed, with a beautiful surrounding wall of granite, with which three of the finest dry-docks in the universe communicate; and that important dock-yard, which may be said to command the mouths of the Thames and the Medway, from being an unhealthy and detestable place, and wholly inefficient for its purpose, is now, by being raised many feet, and laid out with skill and judgment, one of the most convenient in the kingdom. He also planned the new naval arsenal at Pembroke, which is considered as a perfect model for a building-yard. But his plan for the projected naval arsenal at Northfleet on the Thames was far superior to all in design; and on a scale so grand as to be capable of containing afloat two-thirds of the whole navy, with dry-docks and slips for repairing and building ships of all classes to the same extent; with all manner of storehouses, workshops, and manufactories of all such articles as were required for consumption in the navy. But the estimated sum of eight millions, which would probably have amounted to ten, induced the Government to pause, and it was finally deemed prudent to abandon the design altogether.

The late excellent architect and civil engineer, Mr Smeaton, was the first who used the diving-bell effectually for building with stone under water; but the machine he employed for that purpose was very defective, and could be used only in certain situations. But Rennie, by improvements in the instrument itself, and in the machinery by which its movements could be regulated, was enabled to carry on the finest masonry, and the foundations of sea-walls, piers, and quays, as well under water as above it. The repairing of the pier-head of Ramsgate Harbour was a remarkable instance of this kind. The violence of the waves, acting upon the bad quality of the stone, had so completely undermined it, that the stability of the whole pier began to be endangered. It was from ten to thirteen feet below the level of low-water, spring-tides; yet, by means of the improved diving-bell, and its apparatus, the pier-head was not only effectually secured, but rendered more solid and durable than it originally had been. In the harbour of Howth, the diving-bell was of the utmost use; and it is remarkable enough, that the masons who have been for a little while accustomed to work under water prefer it, at least the Irish masons do,

* The Bridge of Neuilly, which the vanity of the French has ranked as superior to that of Waterloo, actually sunk 23 inches.

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to working in the air; it being cooler in summer, and warmer in winter; though an increase of pay for submarine work is probably the real cause of preference.

The last effort of Rennie's genius, to which we shall advert, was the drainage of that vast tract of marsh land bordering upon the rivers Trent, Witham, New Welland, and Ouse, which for centuries past had baffled the skill of some of the ablest men in that department of civil engineering. Upon the same principles, he laid down a grand scheme for draining the whole of that immense district known by the name of the Bedford Level, which has in part been carried into execution by the completion of the Eau-brink Cut, near Lynn. The estimate he made for draining the whole amounted to L. 1,200,000.

Such are some of the grand undertakings which Rennie, during the last thirty years of his life, was either employed to project or to carry into execution, and which, on a rough estimate, collected from his valuable *Reports*, did not fall far short of forty millions Sterling; about twenty millions of which were expended under his own immediate superintendence. Indeed, few great works were carried on, either by the public or individuals, on which he was not either employed or consulted. His industry was very extraordinary. Fond of the society of his select friends, and of rational conversation, he never suffered amusement of any kind to interfere with his business, which seldom engaged less than twelve hours, and frequently fifteen in the day. His conversation was always amusing and instructive. He possessed a rich fund of anecdote, and, like his old friend James Watt, told a Scotch story admirably. As a travelling companion, he was highly entertaining; he knew every body on the road, and every body knew John Rennie. Of an ardent and anxious mind, and naturally impetuous, he was gifted with the most perfect self-control; and the irritation of the moment was seen but as a light summer's cloud, passing across his finely marked features, which were on so large a scale, though blended with much mildness as well as dignity, as to obtain for his noble bust by Chantrey, when exhibited in Somerset House, the name of *Jupiter Tonans*.

Were we to seek for a parallel to Rennie, the name of Smeaton would at once suggest itself. Their boyhood was employed precisely in the same manner, in making models of pumps and windmills, while their school-fellows were at play; their pursuits in manhood were similar, and their paramount success pretty nearly the same: but the spirit of speculation and improvement was but just springing up, when Smeaton finished his career, and when Rennie began his. He was, in fact, the successor of Smeaton. There was a strong characteristic likeness between Rennie and the late Mr Ramsden. The pursuits of the former embraced a wider sphere of action, but they both arrived at their proposed objects by the most simple and obvious, and, at the same time, most effectual means. They were both equally clear in their mode of communicating information to others; and it is sufficiently remarkable that, in their illustrations, both of them had recourse rarely to any other instrument than a two-feet rule, which each always carried in his pocket. Many a time has the writer of this article derived instruction from the two-feet rules of John Rennie and Jesse Ramsden. They were both equally communicative, when they saw that information was desired; and nothing like professional jealousy, or selfish feelings, actuated either of these ingenious men, who, on the contrary, were always kind and condescending to the more humble artists of their respective professsions. To foreigners, in particular, the loss of Rennie will be severely felt; for to those who visited England with the view of inspecting her arts and manufactures, he was always ready to afford every information, and all the facilities in his power.

Mr Rennie possessed considerable skill in bibliography, and being a zealous and liberal collector, he succeeded in forming a very valuable library; consisting of the best and rarest books in all the branches of science and art, of voyages and travels, and many curious books in the black-letter; while in his own department, it contained every work of the least merit, in whatever language it might be written. He had, besides, a good collection of mathematical and astronomical instruments, and frequently spoke of erecting an observatory, but did not live to carry his intention into execution. He had for some years laboured under a disease of the liver, which had apparently yielded to the usual treatment, but a relapse took place; and on the 16th October 1821, after a few days illness, he expired without a struggle, in the 60th year of his age.

Mr Rennie, in 1789, married Miss Mackintosh, who died in 1806, leaving a family of seven young children, six of whom are now living. The two eldest, George and John, are successfully following the profession, and promise to tread in the footsteps of their late father.

Sixteen mourning coaches, filled with his friends, mostly men of eminence in the arts, sciences, or literature, followed his hearse to St Paul's, where his remains were interred near those of Sir Christopher Wren. A plain granite slab covers his grave, on which is the following appropriate inscription:

Here lie the mortal remains of
JOHN RENNIE,
Civil Engineer,
F. R. S. L. & E. F. A. S. &c. &c.
Born at Phantassie, in East Lothian, 7th June 1761;
deceased in London 4th Oct. 1821.
THIS STONE
testifies his private virtues,
and records
the affection and the respect of
his family and his friends;
but
the many splendid and useful works
by which,
under his superintending genius,
England, Scotland, and Ireland,
have been adorned and improved,
are
the true monuments
of
his public merit.

(K.)

ROADMAKING. There are few departments of practical mechanics in which every individual, at some period or other of his life, is more immediately interested than in the management of roads and pavements. The mechanical theory of the motions of wheel carriages, and of the nature of the frictions and resistances that they have to overcome, as relating to the ultimate objects for which roads are constructed, may naturally constitute the first section of an essay on this subject; the second will naturally comprehend the best arrangement of the means for attaining those objects, by the form and construction of such roads and pavements as appear to be the most eligible under various circumstances; and the third may be devoted to some historical illustrations of the principal roads which exist, or which have existed, in various parts of the world.

Section I.—*Of the Objects of Roads.*

The grand object of all modern roads is the accommodation of wheel carriages. The construction of foot paths and of bridle roads is so simple as to require very little separate consideration: except that, in cities and towns, the convenience of the inhabitants requires that some pains should be taken to avoid dust, and has generally been a reason for employing pavements in preference to gravel roads, which might in some other respects be more eligible.

For facilitating the motion of carriages, the most essential requisite is to have the road as smooth, and as hard, and as level as possible. The wheels of carriages are principally useful in diminishing the friction of the materials; a dray sliding without wheels, even on a rail road of greased and polished iron, would have to overcome a friction as much greater than that of the wheel on its axle, as the diameter of the wheel is greater than that of the axle. The wheels assist us also in drawing a carriage over an obstacle; for the path which the axis of the wheel describes is always smoother and less abrupt than the surface of a rough road, on which the wheel rolls, and so much the smoother as the wheel is larger, since the portions of larger circles, which constitute the path in question, are less curved than those of smaller ones.

But in all common cases of roads not extremely hard, by far the greater part of the resistance, actually exhibited by a road to the motion of a carriage, is that which depends on the continual displacement of a portion of the materials from their inelasticity, which causes them to exert a continual pressure on the fore part of the wheel, without rising behind it to propel it forwards by its reaction, as an elastic substance would do. Hence, in a soft sand, although the axles of the wheels may move in a direction perfectly horizontal, the draught becomes extremely heavy. The more the wheel sinks, the greater is the resistance, and if we suppose the degree of elasticity of the materials, and their immediate resistance at different depths, to be known, we may calculate the whole effect of their action on the wheel, and the force that is required to displace them, in the progressive motion of the carriage. Thus, if the materials were perfectly inelastic, acting only on the preceding half of the immersed portion of the wheel, and their immediate pressure or resistance were simply proportional to the depth, like that of fluids, or that of elastic substances compressed, the horizontal resistance would be to the weight nearly as two fifths of the length of the part immersed at once, in the newly formed rut, to the diameter of the wheel; or, on a still more probable supposition respecting the greater resistance of the more deeply seated parts of the rut, about half as much as this, or as about one fifth of the length of the part immersed in the rut to the diameter. Thus, if a coach or waggon, weighing sixty hundred weight, supported by wheels four feet in diameter, formed a new rut, an inch deep, in a smooth road, the length of the part immersed being about fourteen inches, the resistance would be about $\frac{1}{17}$th of the weight, upon the lowest supposition that is at all admissible, and more probably about one ninth, or from six to seven hundred weight at least; and if the rut were two inches deep, the resistance would be half as much more. But, on any supposition, the increased height, and even the increased breadth of the wheel, is calculated to diminish the resistance, by diminishing the depth of the part immersed: thus, if a wheel were made four times as high, the length of the part immersed, considering the road as an imperfect fluid, would be doubled, and the resistance would be diminished, theoretically speaking, to about half of its former magnitude; and if the breadth were increased from one to eight, the length of the part immersed would be diminished to about a half, and the resistance would in this case also be reduced to a half.

In soft and boggy soils, as well as in sandy roads, this consideration is of great importance; and the wheels employed for removing heavy weights, in such cases, ought to be as high and as broad as possible consistently with sufficient lightness and economy. But whether a broad, and, at the same time, a low roller, possesses any advantages above a narrow coach wheel, is a matter much more questionable; it must be remembered that a narrow wheel may often run between stones, where a broader would have to pass over them; and there appears to be no theoretical reason for preferring a low roller, except with respect to a single pair of wheels, as affording a more convenient attachment for the shafts in a moderate inclination, which is both more favourable to the exertion of the horses, and more effective in overcoming the friction; since it has been demonstrated that the angle affording the most advantageous line of draught is exactly the same as the inclination of a plane along which the carriage would just begin to descend by its own weight on the same kind of surface. In fact, however, there is no necessity for fixing the axletree precisely in the line of draught; and the principal reason for having the fore wheels lower than the others is for the convenience of turning the carriage more abruptly. A very accurate practical roadmaker has observed, that a good road never suffers from narrow wheels with moderate weights not in rapid motion, but that it is equally worn by the rapid driving of heavy stage coaches, and by the slow grinding of the conical rollers of overloaded, broad-wheeled waggons.

Such being the operation of the wheels of car-

riages on sandy or on rough roads, it is easy to perceive how much the hardness and smoothness of the surface must facilitate the draught; it is obvious also that the same qualities must be equally conducive to the durability of the road, since the inequalities will always cause the carriage to fall on it with a certain impetus after being elevated by the irregularities, and the same shock which strains the carriage will also tend to wear away the road still more where it is lowest; and, on the other hand, the resistance of the soft materials before the wheel will tend to tear up the road, as it causes the wheel to thrust them before it.

It happens not very uncommonly that the interests of the traveller and the postmaster are somewhat at variance with respect to the qualities of a road. The French postillion keeps to the rough pavement as long as the aching limbs of the ladies in the carriage will allow them to be silent, except when, in going down hill, he saves himself the trouble of locking the wheel, by bringing it to the soft edge of the ditch or kennel; and the horses of the Parisian cabriolets, in their excursions to the suburbs, have sagacity enough to incline always to the pavement, when their drivers allow them to have a will of their own; while a single horseman, on the contrary, more commonly finds his steed on the gravel road, if he happens to leave him to his own direction. In Great Britain the roads are commonly managed by commissioners, who have no community of interest with the innkeepers; on the Continent they are universally under the immediate direction of the different governments, who also appoint the postmasters, while the carriages are almost as uniformly the property of particular individuals, who have no immediate influence on the management of the roads; and this diversity may perhaps explain, in some measure, the different systems of roadmaking which prevail on the opposite sides of the Channel. But it may be said of roads as of governments, "that which is best administered is best;" whether a very smooth pavement not too slippery, or a very hard gravel road not worn into great inequalities.

Sect. II.—*Of the Mechanical Formation of Roads.*

The only strongly marked division of the different kinds of roads depends on their being paved or gravelled; but each of these classes admits of considerable diversity in the principles on which the road is constructed. The theory of pavement appears to be extremely simple; the stones, however, may be either small or large; the former being understood to be employed without previous preparation of their shape, as in the inferior kind of work which is called "pitching" in the west of England; the latter being more or less cut to fit each other, whether in the form of thick rough blocks, not very remote from cubes, or of flat and smooth flagstones: in the cities of Great Britain the former are commonly used for horse pavements, and the latter for foot passengers; but in Florence the whole breadth of the streets is paved with flagstones placed diagonally, and in Naples the surfaces are nearly as smooth; in both these cases it is necessary to roughen the stones frequently with chisels wherever there is a hill or a bridge, in order to prevent the horses slipping, but in both cities the horses from habit are sufficiently sure-footed, even when running with some rapidity. In Milan both kinds of pavements are mixed in the same streets; the smooth in two double lines, for the wheels of carriages coming and going, and the rougher in the intermediate parts, for the feet of the horses, as in the British railroads. But in none of these cities is there much heavy traffic to wear these well arranged surfaces into such inequalities as would probably soon be observed in the streets of London, if they were so delicately formed; although, until this deterioration actually took place, the locomotion would be luxurious both for the horses and for the passengers, and only ruinous to the coachmakers. The Romans used large and heavy blocks for their roads, cutting them on the spot into such forms as enabled them to be best adjusted to those of the neighbouring stones, though seldom exactly rectangular in their surfaces; and even at Pompeii, where the ruts are worn half through the depth of the blocks, the bottom remains tolerably even, in a longitudinal direction, at least as much so as would be required for carts and other carriages of business.

Our more particular object, however, at present, is the consideration of gravel roads rather than of pavements; the word gravel being here understood to mean in general all stone broken small, whether by nature or by art. The improvement of such roads has long been a subject of great interest with the agricultural and commercial inhabitants of Great Britain. It was soon after the year 1700 that a part of the charge of repairing roads was taken off the respective parishes through which they pass, and levied on the general traveller by means of turnpike gates; but it was for many years a complaint that the roads were little, if at all, fundamentally improved by the expenditure of the money so raised. This complaint is very energetically advanced in *A Dissertation concerning the present State of the High Roads of England, especially of those near London, wherein is proposed a new Method of repairing and maintaining them; read before the Royal Society in the Winter of* 1736-7, by Robert Phillips, and printed in a small separate volume. The author's great object is to recommend washing the roads by a constant stream if possible, and at any rate, washing the materials of which they are composed; in this respect, notwithstanding the existence of single roads so situated that the effects of water upon them have been very beneficially introduced, his plans for the universal employment of water have been altogether superseded by later experience; but he remonstrates, with great propriety, against the practice, which has, however, continued to prevail so generally even of late years, of laying down large heaps of unprepared gravel, to be gradually consolidated into a harder mass, at the expense of the intolerable labour of the poor animals that are obliged to grind it down. As an illustration of the good effect of water, he mentions that even the sediment deposited by it at the bottom of Fleetditch, which was supposed to be a soft mud, and to require removal when the ditch was

filled up, proved in fact to be a hard gravelly substance, which afterwards afforded an excellent foundation for the roads and buildings supported by it.

The attention of the public has been more lately directed to the subject of roads and carriages by several essays which appeared in the *Communications of the Board of Agriculture;* they principally belong to the names of Beatson, Wright, Jessop, Hall, Wilkes, Erskine, Ellis, Cumming, Whetley, Amos, and Booth: the most remarkable are Mr Wilkes's *Remarks on the Advantages of Concave Roads;* Mr Ellis's *on Washing Roads;* Mr Wilkes's *on Railways;* and Mr Cumming's *on Wheel Carriages;* showing particularly the disadvantage of broad conical wheels, and the historical progress of the practice of bending the line of the axes.

But all these improvements, whether real or imaginary, have of late been in a great measure superseded by the ingenuity and success of Mr Loudon Macadam, a gentleman whose practice is in general principally to be applauded for its obvious simplicity and economy, though he has also had the merit of discovering that the simplest and cheapest methods, in particular cases, especially in that of boggy soils, are also the most scientific and the most effectual. The practical observations, which are to be here inserted, cannot therefore be so well expressed in any other form, as in that of an abstract of Mr Macadam's own directions.

Mr Macadam's leading "principles are" (*Remarks*, p. 37), "that a road ought to be considered as an artificial flooring, forming a strong, smooth, solid surface, at once capable of carrying great weights, and over which carriages may pass without meeting any impediment."

He proceeds to give directions for repairing an old road and for making a new one, in the form of a communication to a Committee appointed by the House of Commons, in the year 1819, with some subsequent corrections.

No additional materials, he observes, are to be brought upon a road, unless in any part of it there be not a quantity of clean stone equal to ten inches in thickness.

The stone already in the road, supposing it to have been made in the usual manner, is to be loosened and broken, so that no piece may exceed SIX OUNCES in weight; the road is then to be laid as flat as possible, leaving only a fall of three inches from the middle to the sides, when the road is thirty feet wide. The stones, thus loosened, are to be dragged to the side by a strong heavy rake, with teeth two inches and a half in length, and there broken; but the stones are never to be broken on the road itself.

When the great stones have been removed, and none are left exceeding six ounces in weight, the surface is to be made smooth by a rake, which will also settle the remaining materials into a better consistence, bringing up the stone, and letting the dirt fall down into its place.

The road being so prepared, the stone that has been broken by the side is then to be carefully spread over it; this operation requires very particular attention, and the future quality of the road will greatly depend on the manner in which it is performed; the stone must not be laid on in shovels full, but scattered over the surface, one shovel full following another, and being spread over a considerable space.

Only a small part of the length of the road should be *lifted* in this manner at once; that is, about two or three yards; five men in a gang should be employed to *lift* it all across, two continually digging up and raking off the large stones, and preparing the road for receiving them again, and the other three breaking them at the side of the road. It may, however, happen, that the surveyor may see cause to distribute the labour in a proportion somewhat different.

The only proper method of breaking stones, in general, both for effect and for economy, is in a sitting posture. The stones are to be placed in small heaps, and women, boys, and old men past hard labour, may sit down and break them with small hammers into pieces not exceeding *six ounces* in weight. When the heavy work of a quarry can be performed by men, and the lighter by their wives and children, the stone can be obtained by contract for two thirds of the former prices, although the stones were then left four times as large. It has also been recommended by Mr Macadam and others (p. 35), that the largest stone employed should not exceed the measure of an inch in its greatest dimensions, or in other words, that it should be capable of being contained in a sphere of about an inch in diameter, which would seldom weigh more than a single ounce.

In some cases, it would be unprofitable to lift and relay a road, even if the materials should have been originally too large; for example, the road betwixt Bath and Cirencester was made of large stones, but so friable, that in lifting they would have fallen into sand; in this case, Mr Macadam merely had the higher parts cut down, and replaced when sifted (p. 107), and the surface kept smooth, until those materials were gradually worn out; and they were afterwards replaced by stone of a better quality, properly prepared. At Egham, it was necessary to remove the whole road, in order to separate the small portion of valuable materials from the mass of soft matter in which they were enveloped, and which was carried away, at a considerable expense, before a good road could be made. But although freestone is by no means calculated to make a durable road, yet, by judicious management, it may be made to form a very good road as long as it lasts. (p. 103.)

Whenever new stone is to be laid on a road already consolidated, the hardened surface is to be loosened with a pick, in order to enable the fresh materials to unite with the old.

A new road, however well it may have been made, will always receive the impressions of the carriage wheels until it is hardened; a careful person must, therefore, attend the road for some time, in order to rake in the tracks made by the wheels; that is, as long as any loose materials are left that can be so employed.

It is always superfluous, and generally injurious, to add to the broken stone any mixture of earth, clay, chalk, or any other matter, that will imbibe water, and be affected by frost; or to lay any thing

whatever on the clean stone for the purpose of binding it; *for good stone, well broken, will always combine by its own roughness into a solid substance*, with a smooth surface, that will not be affected by the vicissitudes of weather, or disfigured by the action of wheels, which, as they pass over it without a jolt, will consequently be incapable of doing it any considerable injury.

The experience of the year 1820 strongly confirmed the inutility and inconvenience of employing chalk with the stone. In January, when a hard frost was succeeded by a sudden thaw, a great number of roads broke up, and the wheels of the carriages penetrated into the original soil; in particular it was observed, that all the roads, of which chalk was a component part, became nearly impassable; and even roads made over chalky soils gave way in most places. But not one of the roads, that had been thoroughly made after these directions, was observed to give way. (p. 44, 46.)

The TOOLS required for lifting roads are, 1. Strong *picks*, but short from the handle to the point. 2. Small *hammers*, weighing about a pound, with a face the size of a shilling, well steeled, and with a short handle. 3. *Rakes*, with wooden heads, ten inches in length, and with iron teeth, about two and a-half inches long, and very strong, for raking out the large stones when the road is broken up, and for keeping it smooth after it has been finished, and while it is consolidating. 4. Very light broad mouthed *shovels*, to spread the broken stones, and to form the road.

The whole EXPENSE of lifting and newly forming a rough road, to the depth of four inches, has generally been from a penny to twopence *per* square yard, being more or less, according to the quantity of stone to be broken. With proper tools, and by proper arrangements, stone may be broken for tenpence or a shilling *per* ton, including, in some cases, the value of the stone itself. A very material advantage of Mr Macadam's method is the introduction of a much greater proportion of human labour, instead of the work of horses: formerly one fourth of the whole expense was paid, in the district of Bristol, for men's labour, and three fourths for that of horses: now, on the contrary, one fourth only is paid for horses' labour, and the other three to men, women, and children.

Mr Macadam argues very strongly against the old opinion, of the necessity of placing a quantity of large stones, as a foundation, to carry the road over a wet subsoil. He says, that whatever be the nature of the soil, if it be previously "made quite dry," and a covering impenetrable to rain placed over it, the thickness of the covering needs only to depend on its own capability of becoming impervious. Large stones, he says, will constantly work up by the agitation of the traffic on the road, and leave vacuities for the reception of water; and the only way of keeping the stones in their places, is to have them of a uniform size. A rocky bottom causes a road to wear out much the faster [acting, probably, as a lower millstone in facilitating the operation of grinding]. "It is a known fact, that a road lasts much longer over a morass, than when made over rock. In the neighbourhood of Bridgewater, for example, the materials consumed on a rocky road, when compared with those which are required for a similar road made over the naked surface of the soil, are in the proportion of seven to five."

In the summer of 1819, upon some new roads made in Scotland, more than three feet of materials, of various dimensions, were laid down; and more than two thirds of them, according to our author, were worse than wasted. In such an arrangement, the water generally penetrates to the bottom of the trench made to receive the road, and remains there to do mischief upon every change of weather.

To prevent such inconveniences, it is necessary in wet soils, either to make drains, to lower ground, or to raise the road above the general level, instead of making a trench to receive the stones; and from the penetration of rain the solidity of the road itself must protect it. A well made road, not quite four inches in thickness, was found to have kept the earth below it dry in the parish of Ashton near Bristol: but six, eight, or ten inches of materials are generally required to make a firm road; being laid on in successive layers of about two inches in thickness, all well broken, well cleaned, and well sized. Sometimes, indeed, a much greater depth of stone than this is required: in a road, for example, which has lately been made from Lewes to East Bourn, entirely upon Mr Macadam's principles, as much as three feet of materials was required in many parts before the road could be sufficiently consolidated; it has, however, ultimately been made excellent, though at an expense of not much less than a thousand pounds a mile.

Mr Macadam maintains that the quantity of stone required for paving is fully sufficient to make an excellent gravel road in any part of the world; and in almost every case, materials equally good can be obtained for roads at a still cheaper rate; commonly, indeed, at one tenth of the expense of pavements. It is, however, in steep ascents that pavements are most objectionable; at the north end of Blackfriars' Bridge, more horses are said to fall and receive injury than at any other place in the kingdom. In the suburbs of Bristol the pavements have lately been converted into roads with great success. It is probable that neither the inhabitants of these suburbs nor their housemaids were much consulted on the occasion, although justice seems to require that the pedestrian order should not be altogether sacrificed to the equestrian without their consent; but, in fact, the inhabitants of these *ci-devant* streets are said to be well satisfied with the change; and we seem in danger, from the opposition of contending theories, of having all the streets of our cities dug up, and many of our country roads, on the other hand, encumbered with pavements. Mr Macadam has received a new encouragement from Parliament to the amount of L. 4000, and not Charing Cross, indeed, but St James's Square, is going to be Macadamised without delay.

We find some further confirmations and illustrations of Mr Macadam's principles and precepts in the *Report* of the former Committee of the House of Commons as reprinted in his *Remarks*.

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This gentleman, it seems, arrived from America in the year 1783, at the time that many new roads were making in Scotland (p. 97); he was then appointed a commissioner of the roads, and studied the subject in that capacity there; he has since resided chiefly in Bristol, and was induced to take charge of the roads of that district as a surveyor in 1816; because it was nly in that situation that he could carry his principles into practice, and make the necessary experiments for establishing them. He observed in his travels, that the mixture of clay and chalk, with the materials of roads, was the almost universal cause of their failure; and he convinced himself that, by a proper application of materials, a good road might be made in every country. His improvements have been very generally adopted in the west and the south of England; and principally under his own direction or under that of his family. They had superintended more than 300 miles of road, and twice as many more had been improved by their advice and influence. Sober, active, and well informed subsurveyors he considers as the most important of all materials for a good road; and among the extrinsic arrangements which are often required, he thinks the union of different trusts into a single one the most likely to be generally beneficial.

The operation of washing gravel Mr Macadam has not found eligible, because it is more expensive than screening or sifting, and less effectual; for about London the common gravel is not capable of being cleaned by any ordinary washing, though the Thames gravel, where it can be procured, is generally clean and serviceable. Coarse gravel broken, he says, is preferable to fine, as it consolidates more perfectly into a single mass. The old practice of putting a heap of unprepared gravel along the middle of the road, and letting it work its own way gradually to the sides, he thinks every way reprehensible.

The objection to a very convex road is, that travellers only use the middle of it, which is, therefore, worn into three furrows by the string of horses, and by the wheels; if the road is flatter, it becomes worn more equally. Ditches, he observes, only require to be so deep that the surface of the water in them may be a few inches below the level of the road; the farmer often makes them dangerously deep on account of the value of the mould that is dug out of them. Mr Macadam would prefer a bog to any other foundation for a road, provided that it would allow a man to walk over it; and he justly observes, that the resistance to the motion of a carriage would not be materially affected by the foundation, if the road were well made. From Bridgewater to Cross, a part of the road shakes when a carriage passes over it; yet the consumption of materials is less there than on the limestone rock in the neighbourhood. He does not use any faggots in such cases, nor any stones larger than six ounces in weight; and these never sink in the bog, but unite into one mass like a piece of timber, which rests on it. He makes such a road generally at three different times: and he always prefers working in weather not very dry. The surveyors are directed to carry a pair of scales and a six ounce weight in their pockets, as a check upon the workmen.

Mr Macadam has generally found reason to approve the usual regulations respecting carriage-wheels: but he thinks broad wheels less advantageous to roads than is commonly supposed. He suggests that the tolls might always be fairly made proportional to the exact number of horses employed; except that the waggoners should be encouraged to harness them in pairs rather than in a line. The conical form of broad wheels he thinks very injurious.

Clean flints from the sea side are among the best materials for roads, and might often be procured cheap by canals: granite chippings also, brought as ballast, are excellent; and when the middle of the road has been well made with good stones, the sides may often be left for a few feet less abundantly provided with them, as they are naturally much less exposed to wear.

Of the other evidence produced to the Committee of the House of Commons, there is much that gives us valuable information respecting the economy of horses and carriages in general, and some that deserves to be noticed, as affording partial exceptions to the universal adoption of the system introduced by Mr Macadam.

Mr Waterhouse observes (p. 85), that stage coach horses generally last about four years in the neighbourhood of London, and about six in remoter parts. He agrees with Mr Macadam, that a very slight convexity is better for a road than a greater: that roads in wet situations often require underdraining; and that the gravel near London is too often used without being sufficiently cleaned. Mr Horne's horses generally wear out in about three years. The "light" coaches, with their loads, generally weigh about two tons and a half; the coach one, the passengers one, and the luggage a half; the Uxbridge road, he says, is generally heavy, because it lies lower than the neighbouring land, and is not sufficiently drained. Mr Eames reports, that the Guildford road is so much improved by the introduction of flints instead of gravel, that sixteen miles are as easily performed on it by his horses as twelve were before the alteration. Mr Farey explains the principle upon which some of the roads about London are watered in winter; it is in order to soften the tenacious mud, that is formed upon the surface; to prevent its adhering to the carriage wheels, and to enable it to be scraped off with ease. He says that about Whitechapel it has been found very advantageous for the heavy traffic, to have the middle of the road paved; and he thinks that two lines of pavement, one on each side, would be preferable to a single one, in order that the waggoners might walk at the sides of the road, leaving the middle for lighter carriages. He would have a road 55 feet wide, elevated about 12 inches in the middle Broad wheels, he thinks, are seldom so flat as to bear on their whole surface at once, being commonly rather conoidal than conical; so that they differ less in their effect from narrower wheels than is commonly supposed. Mr Walker adheres to the old opinion, that in soft soils a road ought to be founded on bushes or "bavins;' that is, where they can be ex-

pected to remain always wet, so as not to be liable to a very speedy decay. He observes, that if a road does not possess some considerable convexity at first, it will wear concave, and collect mud; the elevation, he thinks, should be about $\frac{1}{30}$th of the breadth. Mr Telford informs the committee (p. 188) that the declivity of the Welsh roads was formerly in many places one inch in ten; and in some one in eight, and even one in six; but that the modern road scarcely ever rises above an inch in thirty; and that the utmost ascent in the whole line is one in seventeen, for about two hundred yards. With respect to the weight of the stones, he agrees with Mr Macadam, that they ought not to exceed six or eight ounces; and that gravel is best cleaned by riddling it repeatedly, and leaving it to dry in the intervals.

Sect. III.—*Of the Roads of different Ages and Countries.*

The Romans appear to have been beyond comparison the greatest roadmakers of the ancient or the modern world. The story told by Montaigne (III. vi. p. 206) of a road in Peru, from Quito to Cusco, 300 leagues long, and 25 paces broad, made of stones 10 feet square, with a running stream and a row of trees on each side, seems to have been considerably exaggerated; and it is not very clear whether the stones he mentions were used for the road or for the houses of entertainment built at intervals by its side; nor have the "rocks cut through" and "mountains levelled" been very particularly noticed by more recent travellers in that country. In Italy only, the Romans are said to have made more than 14,000 miles of road, which was generally executed with great care and labour; and many of their roads still remain as the foundation of the most favourite routes of Italian travellers. The more than Roman despot of modern times was as much a Roman in his roadmaking as in the selfish character of his general policy; and in proportion to the duration of his dynasty, he performed more than all the Appii and Flaminii of antiquity. Whatever his merits may have been, the beneficial effects of his measures remain, and those who have profited by his improvements have no right to criticize his motives with too great severity.

Of the great roads diverging from the gates of ancient Rome, about twelve have been enumerated by antiquaries, and twelve more branched off from these at a small distance from the city; eighteen others commenced in different parts of Italy, and in the whole there are at least fifty, which have been distinguished by appropriate names, without including the military roads through the distant provinces; such, for example, as in England were distinguished by the name of streets, of which many traces yet remain in different parts of the country.

Directly to the sea the Romans travelled by the Ostian road; along its shores to the north west by the Aurelian, and to the south east by the Appian. Next within the Aurelian was the Flaminian, then the Salarian, the Nomentanian, the Tiburtine, the Praenestine, the Lavican, and the Latin; and then the Appian, which was the most ancient of all, having been made as far as Capua, in the 442d year of the city, accompanied to a considerable distance by an aqueduct. The Aurelian road was made in the year 512; the Flaminian about 533.

I. The *Flaminian* road still affords the great northern approach to Rome by the Porta del Popolo; it led to Foligno, Aneona, and Rimini, and was continued by the *Emilian* to Bologna, and thence to Aquilegia, near Venice; the present mountain route from Bologna to Rome is still facilitated by the remains of the ancient structures. Besides the Emilian road, the Flaminian was also connected with the *Cassian*, leading to Modena; the *Claudian* to Arezzo, Florence, and Lucca; there were also six other branches of less note, each named after its founder.

II. III. The *Salarian* and the *Nomentanian* roads lay to the east of the Flaminian; the former, from the Porta Salara, led through the country of the Sabines by Rieti to Hadria; the latter from the Porta Sant' Agnese went north eastwards to Nomentum.

IV. The *Tiburtine* road led from the Porta Tiburtina, now San Lorenzo, to Tivoli, with a branch on the right called the Gabian. The large blocks which were employed to form this road, near the town of Tivoli, in ascending from the river, are still in their ancient places; they are accurately fitted together, and present a surface sufficiently smooth, after having been in use for about two thousand years.

V. VI. VII. The three next in order all met at Anagnia, 24 miles beyond Praeneste or Palestrina. The *Praenestine*, from the Esquiline gate, now called Porta Maggiore, on account of the magnitude of the ruins of the aqueduct of Clodius, with which it is incorporated, led by Aquinum to Praeneste; the *Lavican* led from the same gate, more to the right, by way of Beneventum; and the *Latin* road, from the Porta Latina, went first to Compitum; and from Anagnia proceeded to join the Appian near Capua.

VIII. The *Appian* road is as well known from the minute description of Horace's progress, in his journey to Brundusium, as from the eagerness with which a modern traveller reckons the stages that he has completed, on his way to Naples, without a visit from the banditti that infest it. The original extent of this road, from the Colosseum to Capua, was 142 Roman miles; and it was continued 238 miles further to Brundusium by Julius Cæsar. It was constructed with large stones, or rather rocks, joined together with great care; and it is said to have had a foot pavement two feet wide on each side, besides the agger, or principal mass of stones in the middle, and the two marginal parts, which were probably unpaved.

IX. The *Ostian* road led from the Porta di San Paolo, near the Tiber, in a straight line to the mouth of that river.

X. The *Aurelian*, from the Porta Aurelia, a gate which was near the Moles Adriani, or Castle of Sant' Angelo, led by Laurentum to Centumcellae, or Civita Vecchia, to Genoa, and thence by Susa, across the Montcenis, as far as Arles in Provence. This seems to have been the oldest passage into the Gauls; it was improved by Pompey the Great under the name of the Strata Romana. Several other passages over the Alps are also particularised in the *Itinerary* of Antonine on the roads from Milan to

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Arles; from Milan to Vienne in Dauphiné, either by the Grecian or by the Cottian Alps: the former north, the latter south of Montcenis; from Milan to Strasburg; and from Milan to Mentz.

XI. XII. The *Triumphal* road began from the Capitol, and went over the Tiber into the country beyond the present site of the Vatican. We may consider as the last of the twelve great roads, originating from Rome, the *Collatine,* leading due north from the Porta Pinciana on the Monte Pincio.

Among the less remarkable roads about the metropolis of the ancient world were also the Campanian, the new and the old Valerian, both leading by Tivoli to the Adriatic; the Tusculan, the Alban, the Ardeatine, on the right of the Appian; the Laurentine, a little more to the right, Pliny's villa being mentioned as accessible from either of these last; the Portuensis, from the Porta Portuese Trasteverina, leading to Ostia; and the Aurelia Nova, beginning from the Porta Janiculi, now Porta San Pancrazio, and leading towards Civita Vecchia.

Whether on the foundations of the ancient roads, or in any new lines that have been prepared in modern times by the magnificence of the Pontiffs or of the Princes, the great roads of Italy are at present almost universally well made and well repaired. In Lombardy, indeed, and throughout the immense plain that extends from the Alps to the Apennines, they are quite as good, in summer at least, as in England. The cross roads of Italy are, however, greatly neglected; for it is in fact almost exclusively in Great Britain that private and individual exertion supersedes the necessity of public munificence. The intercourse of Italy with the rest of Europe has been greatly facilitated by the improvements made in the two great passages over the Alps by the authority of Bonaparte. The more useful of these improvements are probably those which have been effected on the southern side of Montcenis, since they enable the traveller to pass with little danger or difficulty at all seasons of the year; the more magnificent are the works at the Simplon, which, however, are not completely secure from the danger of *avalanches,* whenever fresh snow is lying on the ground. The Apennine portion of the Aurelian road has also been greatly improved by some still more recent operations, so that carriages may now pass with comparative ease and safety from Lucca to Genoa; though, for one stage, near Sestri, it is not thought advisable for the travellers to retain their seats within them.

The general declivity of the new road over Montcenis is 1 inch in 15 or 20; and it is never greater, in the steepest part, that is, in the fourth and fifth turns that wind up over Lanslebourg, than 1 in 12.* The road over the Simplon was executed jointly by the French and Italians, under the government of Bonaparte, from 1801 to 1805. The greatest declivity is 1 inch in 29; so that an English stage coachman might trot his horses up almost the whole way. The longest gallery or tunnel is about 500 feet underground.

The roads in France are generally rough in their original formation, and still rougher from want of care in repairing them, as the traveller feels to his cost in passing over the primitive mountains in the south of that country, where the roads are certainly very different from those which are made by Macadam across a bog; although some of the more recent French and Flemish pavements, as long as they remain unimpaired, are truly excellent: the new pavement between Cologne and Brussels, for example, is far more perfect than some of the unpaved parts of the continuation of the same line of road to Calais, although the civil postmasters are in the habit of congratulating their English guests on the "fine gravel road" they will have to pass over. In Germany they have few pavements, and the roads, except in sandy countries, are generally kept, or keep themselves, in good repair; that is, in the south and the west of Germany. Mr Cripps informs us, that the great roads in Sweden are beautiful; they are very slightly convex, and made of granite broken to the size of a walnut. The Irish roads, according to Mr Edgeworth, are generally better than the English; the Scotch, Macadam thinks worse, though the materials are better; but in many parts of Scotland the roads appear to be more than sufficiently good for the commerce of the country.

[Bergier, *Histoire des Grands Chemins de l'Empire Romain,* 2 vols. 4to. Brussels, 1728: died in 1622. *Considerations on Roads,* 8vo. Lond. 1734. Phillips's *Dissertation concerning the High Roads,* 8vo. Lond. 1737. Homer's *Inquiry into the State of the Roads,* 1767. Lambert *On the best Ascent of Roads,* Ac. Berl. 1776. Meister *On the Shortest Roads to Different Places,* N. Comm. Gott. 1777. Edgeworth *On Roads and Carriages.* Edgeworth *On Rail Roads.* Young's *Natural Philosophy,* II. p. 203: *Instruments for Making and Cleaning Roads. Communications to the Board of Agriculture,* I. 1797; p. 119, Beatson; 162, Wright; 176, Joseph; 183, Hall; 199, Wilkes *On Concave Roads;* Erskine *On Iron Roads;* 205, Wright *On Watering Roads near London;* 207, Ellis *On Washing Roads.* II. 1800; p. 353, Cumming *On Broad Wheels:* 474, Wilkes *On Railways.* VI. 1808; p. 182, Whetley; p. 464, Amos *On Wheels.* VII. 1811; p. 10, Cumming *On the Origin of Bent Axle Trees;* 30, Booth *On Wheel Carriages.* Paterson's *Practical Treatise. Quarterly Review,* May 1820, XXIII. p. 96. Macadam's *Remarks on the Present System of Roadmaking, with Observations deduced from Practice and Experience, with a view to a Revision of the Existing Laws, and the Introduction of Improvement in the Method of Making, Repairing, and Preserving Roads, and Defending the Road Funds from Misapplication.* 6th edit. 8vo. Lond. 1822.]

(A. L.)

Road-making || Robison.

ROBISON (John), a distinguished Professor of Natural Philosophy, born, in 1739, at Boghall, in the parish of Baldernock, and in the county of Stirling, was a younger son of John Robison, Esq. who

* Derrien, *Notice Historique et Descriptive sur la Route de Montcenis.*

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had formerly been a merchant at Glasgow, and had retired to live in considerable affluence on his estate at Boghall, not far from that city.

He was of a family sufficiently respectable to enable his son at a subsequent period to prove himself, to the satisfaction of the Court of St Petersburg, a *gentleman* born. As a younger brother, that son was originally intended for the church, and went at an early age, according to the custom of Scotland, in 1750, to enter as a student of humanity in the University of Glasgow; so that he was initiated almost in the rudiments of Latin and Greek literature under the able instruction of Dr Moore, the well known professor of Greek; and he acquired such a knowledge of these languages as served to constitute him a correct classical scholar through life. He pursued his studies with so much attention, as to obtain the approbation of his teachers, and the admiration of his contemporaries, who were delighted with the originality and ingenuity of his conversation, though he did not himself reflect with perfect satisfaction upon the degree of application which he had exerted in his academical education. He took a degree of Master of Arts in 1756, having studied mathematics under Dr Robert Simson, and moral philosophy under Dr Adam Smith. The example of so correct and rigid a follower of the ancient methods of demonstration, as Dr Simson, must unquestionably have exercised considerable influence on his yet unformed taste in mathematics; but he seems to have had a natural preference, either from the constitution of his mind, or from some previously acquired habits of thinking, for the geometrical method; for we are informed that "he first attracted the regard of Dr Simson by owning his dislike of algebra, and by returning a neat geometrical solution of a problem which had been given out to the class in an algebraical form; with this mode of solution the professor was delighted, though the pupil candidly acknowledged that it had been adopted only because he could not solve the problem in the manner required of the class."

He had imbibed, in the course of his studies, an insuperable aversion to the pursuit of his original objects in the church; not certainly from any want of religious feeling, or from a dislike to the kind of life that was intended for him, but probably from some difficulties that had occurred to him respecting particular points of doctrine or of practice. He was therefore compelled to provide himself with some other occupation; and he readily accepted the offers of some of his friends in 1758, to recommend him to Dr Blair, a prebendary of Westminster, who had formed a scheme for sending Prince Edward, the young Duke of York, to complete his professional education at sea, in company with a son of Admiral Knowles; and Mr Robison was to have instructed his Royal Highness in mathematics and navigation. He was much disappointed, on his arrival in London, to find that the expedition had never been seriously intended; and he readily accepted an engagement to attend young Knowles as a private tutor, when he went as a midshipman on board of the Neptune of 90 guns, with Admiral Saunders, who had the command of a force intended to co-operate with General Wolfe in the reduction of Quebec; and upon the appointment of his friend as a lieutenant on board of the Royal William, Robison was himself rated as a midshipman in that ship.

Robison.

The fleet arrived on the coast of America in April 1759; in May they got up the river, and Mr Robison was one of a party of 100 seamen draughted from the Royal William into the Admiral's ship, under the command of Lieutenant Knowles: in this capacity he had an opportunity of seeing considerable service, and of making some surveys of the river and of the neighbouring country, an employment for which he was perfectly qualified, both as a geometrician and as a draughtsman. He also remarked the effect of the Aurora Borealis on the compass, which had been noticed by Mairan and Wargentin some years before, but which was then not commonly known. After the battle, which was signalised by the victory and death of the gallant Wolfe, the Royal William sailed with his body to Europe, and arrived at Spithead in November. The next year she was sent to cruise off Cape Finisterre, but in six months she was obliged to return home, from having the greater part of the men disabled by the scurvy.

He used to consider the two years that he spent on board of the Royal William as the happiest of his life; and no inconsiderable part of his gratification was derived from the study of seamanship as he saw it practised under the auspices of Captain Hugh Pigot. He did not, however, acquire any firm attachment to the mode of life which he had temporarily adopted; he was rather disposed to resume his academical pursuits, and he had overcome his earlier objections to the ecclesiastical profession. He could not, however, refuse the friendly invitation of Admiral Knowles to come and live with him in the country, and to assist him in some important experiments which he was making upon mechanical and nautical subjects.

In the month of February 1762, Lieutenant Knowles was appointed to the Peregrine sloop, of 20 guns, and Mr Robison accompanied him with the hope of becoming a purser. He visited Lisbon and several other parts of Portugal; but he found a cruise in a small ship much less convenient and agreeable than in a large one, and, fortunately for himself and for mankind, he finally quitted the Peregrine and the naval service in June, and returned to live with Admiral Knowles; who soon after recommended him as a proper person to take charge of Harrison's timekeeper, which had been completed by the labour of 35 years, after many unsuccessful experiments, and which was now sent out by desire of the Board of Longitude to the West Indies, under the care of young Harrison and of Mr Robison. The rate of the chronometer was ascertained at Portsmouth the 6th November 1762, and it indicated, at Port Royal in Jamaica, a difference of time amounting to $5^h\ 2^m\ 47'$, which is only four seconds less than the true longitude. After a few days, the observers had a prompt opportunity of returning home by the Merlin sloop, which was sent to Europe with despatches. The voyage was most disastrous with respect to wind and weather, and at last the ship took fire; but she arrived safe at Portsmouth in March, and on the 2d of April the watch gave

$11^h\ 58^m\ 6\frac{1}{2}'$, instead of 12^h, for the time of mean noon, so that the error, after six months, was only $1^m\ 53\frac{1}{2}'$, amounting to no more than about 20 miles of distance.

Mr Robison received, upon his return, the afflicting intelligence of the total loss of the Peregrine, which had foundered at sea with her commander and the whole of the ship's company. He was also greatly disappointed in the failure of some hopes which had been held out to him from the Admiralty and the Board of Longitude; though in fact there is little reason for the public to regret that he was not gratified with the pursership, which he claimed as the reward of his services. He was indeed afterwards actually made a purser by Lord Sandwich, in 1763; but he then declined accepting the appointment. His biographers very naturally complain of the neglect of those Boards which ought to have recompensed him; but certainly the Board of Longitude had no power whatever, and probably not much influence, in the appointment of a purser; and after all, the delay of a year or two was nothing very uncommon in the navy.

He had now no other resource than to return to Glasgow, and to resume his academical pursuits with renewed energy. It was from this time that he dated his serious application to his studies; he became extremely intimate with Dr Reid and Dr Alexander Wilson, and he had the advantage of being a witness of two of the greatest steps in the improvement of physical science that have been made in modern times, Dr Black's experimental theory of heat, and Mr Watt's invention of a new steam-engine. Dr Black was the first that determined the quantity of heat required for the conversion of ice into water; Mr Watt, who was settled as a mathematical instrument-maker at Glasgow, had been employed in repairing a working model of Newcomen's engine for one of the professors of the university, and it was the difficulty of supplying this model with steam that suggested to Mr Watt the eligibility of having a separate condenser, and that led him, in conjunction with Dr Black, to a knowledge of the quantity of heat consumed in evaporation.

Amid the enthusiasm which is always inspired by the progress of scientific discovery, and of practical improvement, Mr Robison found every encouragement and every facility for the pursuit of his favourite objects. He was recommended by Dr Black, upon his removal to Edinburgh in 1766, as his successor in the lectureship of chemistry, though without the appointment of a professor. He took charge, also, of the education of Mr Macdowal of Garthland, and of Mr Charles Knowles, afterwards Sir Charles. Admiral Knowles was soon after recommended by the British government to the Empress of Russia, in order to effect a reformation in her navy, having been employed on a similar service in Portugal almost fifty years before; he had always been a firm friend to Mr Robison, and now engaged him on this mission, with a salary of L. 250 a year; and they proceeded together to St Petersburg in December 1770. Being hospitably entertained on their way by the Prince Bishop of Liege, whom they found to constitute, with his chapter and all his servants, a lodge of freemasons, Mr Robison was easily persuaded to become one of that fraternity; in a few days he was made an apprentice, and by degrees attained the rank of Scotch master, as he has himself related in his publication upon the subject. He continued nearly two years at St Petersburg, still acting in the capacity of private secretary to Sir Charles, who was appointed president of the Board of Admiralty, much to the advantage of the Russian navy, though his improvements were frequently retarded by the prejudices of the native officers. Mr Robison was then appointed inspector general of the corps of marine cadets at Cronstadt, with a double salary, and with the rank of Lieutenant Colonel. His duty was to receive the report of about forty teachers and professors, respecting the studies of 400 young noblemen, who were their pupils, and to class them according to his judgment of their merits; but he had himself nothing to teach, nor could he have had much occasion for "lecturing fluently in the Russian language," though he was introduced by his friend Kutusoff to the Grand Duke Paul as a proficient in that language; but to the Empress he was not personally known. At Petersburg he could have lived without regretting his country, in the society of such men as Euler and Alpinus, admired by the Russians, and beloved by the British; but Cronstadt in winter was deplorably melancholy; and he was induced, without much difficulty, in 1773, to make some little pecuniary sacrifice in accepting the professorship of Natural Philosophy at Edinburgh, which had become vacant by the death of Dr Russell, and to which he had been recommended by Dr Robertson, then Principal of the University. His determination was not disapproved by the Russian government, who granted him a pension of about L. 80 a year for life; but it was only paid as long as three or four young men, who had accompanied him as pupils, continued to reside at Edinburgh; some discontent having been expressed because he did not keep up a correspondence with the Academy on the improvement of maritime education.

He arrived at Edinburgh in September 1774; he married soon after, and continued to reside in that city for the remaining thirty years of his life, paying only an annual visit to his native place, where he possessed a part of his paternal estate; not being solicitous to extend it, although "he did not diminish it otherwise than as it had been diminished before," that is, in making provision for younger children. His predecessor had been very judicious and successful as a lecturer, though not a mathematician of the highest order; he had himself more practical knowledge and experience in mechanics, and was better acquainted with the foreign mathematicians, who had naturally fallen under his notice during his residence on the Continent. His lectures were considered by most of his pupils as somewhat too difficult to be followed; a complaint which, if it did not depend on their own want of preparatory information, arose perhaps rather more from the hasty manner of his enunciation, than from the abstruseness of his matter. "The singular facility of his own apprehension," says Professor Playfair, "made him judge too favourably of the same power in others.

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To understand his lectures completely was, on account of the rapidity, and the uniform flow of his discourse, not a very easy task, even for men tolerably familiar with the subject. On this account, his lectures were less popular than might have been expected from such a combination of talents as the author of them possessed." This inconvenience was increased " by the small number of experiments he introduced, and a view that he took of Natural Philosophy, which left but a very subordinate place for them to occupy. An experiment, he would very truly observe, does not establish a general proposition, and never can do more than prove a particular fact:" but he seems to have carried this principle to some little excess: it is, in fact, the *illustration*, and not the *proof*, of general principles that is the object of a public exhibition of experiments; and it is very doubtful whether Archimedes, or Newton, or Leibnitz, or Euler, would have been very successful as *showmen*. With respect, however, to " accuracy of definition, to clearness, brevity, and elegance of demonstration, and even to neatness and precision in experiments," Professor Robison *was* very successful; his course extended " to every branch of physics and of mixed mathematics," and entered so fully into the detail of each particular division of the subjects, that " a more perfect system of academical instruction is not easily to be imagined:" nothing, in short, was wanting, but so much previous knowledge of mathematics in his pupils as he thought he had a right to expect, though his expectations were too rarely fulfilled.

The Philosophical Society of Edinburgh had been almost suffered to sink into oblivion after the publication of the third volume of its *Essays*, in 1756. Professor Robison became a member of it soon after his return from Russia, and was chosen Secretary of the new Society upon its formation by Royal charter, in 1783, when it incorporated with itself the whole of the surviving members of the former Society. In 1798, he received the compliment of a degree of Doctor of Laws from the University of New Jersey; and a similar honour was paid him at Glasgow the year after. In 1800 he was elected, as successor to Dr Black, on the list of the Foreign Members of the Royal Academy of Sciences of St Petersburg.

He was attacked, in 1785, by a severe disorder, from which he was never afterwards wholly free, though it produced little inconvenience besides pain, with some depression of spirits, which was, however, attributed rather to the closeness of his application than to the immediate effect of the disease, which was a glandular induration. For many years he was obliged to obtain the assistance of substitutes in the delivery of his lectures; but towards the end of his life he was able again to perform the duties of the professorship in person. He continued his literary labours with little intermission, and was most happy in the care and attention of his wife and children, whose virtues he found the best alleviation of his sufferings. He took a slight cold, after giving a lecture, on the 28th of January 1805, and died on the 30th.

Robison.

1. It was comparatively late in life that Professor Robison assumed the character of an author, having communicated to the Royal Society of Edinburgh, in 1785, a paper on the *Determination of the Orbit and Motion of the Georgium Sidus*, which was published in the *Edinburgh Transactions*, Vol. I. He had observed the opposition of the planet, in 1786, with an equatorial telescope only, and he had computed the elements of its orbit with greater accuracy than any other astronomer had then done; although his suspicion of the effect of such a planet on the motions of Jupiter and Saturn has not been confirmed by later investigations, the irregularities of these planets, on the contrary, having been otherwise explained.

2. A second paper, published in the same collection, Vol. II. p. 82, relates to *The Motion of Light*, as affected by refracting or reflecting substances which are themselves in motion: the author corrects some errors of Boscovich, who had miscalculated the effect of a water telescope; but he seems to agree with Dr Wilson in the suggestion of another experiment of a similar nature, which, to say the least, is wholly superfluous.

3. The most important, beyond all comparison, of Professor Robison's scientific publications, are the articles which he communicated from time to time to the *third* edition of the *Encyclopædia Britannica*, and to its *Supplement*. It was under the care of Mr Colin Macfarquhar that the twelve first volumes of that edition of this work were published;* and upon his death, in 1793, the task of continuing it was committed to Dr Gleig, to whom Professor Robison became a most essential co-operator, and from that time " the work ceased to be a mere compilation." The first of his contributions, according to Professor Playfair, was the Article OPTICS, but he probably only revised and enlarged that article; it was followed by PHILOSOPHY, which he wrote jointly with Dr Gleig; by PHYSICS, PNEUMATICS, PRECESSION, PROJECTILES, PUMPS, RESISTANCE, RIVERS, ROOF, ROPEMAKING, ROTATION, SEAMANSHIP, SIGNAL, SOUND, SPECIFIC GRAVITY, STATICS, STEAM, STEAM ENGINE, STEELYARD, STRENGTH, TELESCOPE, TIDE, TRUMPET, VARIATION, and WATERWORKS; and in the *Supplement*, by ARCH, ASTRONOMY, BOSCOVICH, CARPENTRY, CENTRE, DYNAMICS, ELECTRICITY, IMPULSION, INVOLUTION, MACHINERY, MAGNETISM, MECHANICS, PERCUSSION, PIANOFORTE, POSITION, TEMPERAMENT, THUNDER, TRUMPET, TSCHIRNHAUS, and WATCHWORK. Notwithstanding some degree of prolixity and want of arrangement, which could scarcely be avoided in the preparation of original articles for such a mode of publication, the whole of them, taken together, undeniably exhibit a more complete view of the modern improvements of physical science than had ever before

* The third edition of the *Encyclopædia Britannica* consisted of eighteen volumes; the *Supplement* to it of two volumes.

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been in the possession of the British public; and display such a combination of acquired knowledge with original power of reasoning, as has fallen to the lot of a few only of the most favoured of mankind.

4. It is not altogether with so high approbation that his friends and his biographers have mentioned a work, of a nature rather political than philosophical, entitled *Proofs of a Conspiracy against all the Religions and Governments of Europe*, 8vo. Ed. 1797; though it went through several editions. The principal part of the book consists of the history of the *Illuminati* and the *German Union*, whom he considers as having become the chief agents in a plot first formed by the Freemasons, at the suggestion of some ex-jesuit, who proposed for their model the internal economy of the order which he had quitted; and whatever foundation this outline may have had in truth, there is no doubt that the manner, in which Professor Robison has filled it up, betrays a degree of credulity, extremely remarkable in a person used to calm reasoning and philosophical demonstration. For example, in the admission of a story told by an anonymous German author, that the minister Turgot was the protector of a society that met at Baron d'Holbach's, for the purpose of examining the brains of *living children*, in order to discover the principle of vitality. He does not accuse the English Freemasons of having participated in the conspiracy; but he considers the Continental lodges as having been universally implicated in it.

5. After the death of Dr Black in 1799, he undertook to superintend the publication of his *Lectures on Chemistry*, which appeared in 1803. 2 vols. 4. And he executed this task, which was rather laborious than difficult, with equal zeal and ability. He endeavoured to reduce to their just estimate the comparative pretensions of the French and British chemists, though he is somewhat puritanically severe in criticizing the literal meaning of the compliments paid to Black by Lavoisier, on which he founds a charge of insincerity.

6. His last publication was the first volume of a series which was to form a complete system, entitled *Elements of Mechanical Philosophy*, 8. Ed. 1804. It comprehended only *Dynamics* and *Astronomy*; and it never became very popular: it was too difficult for the many, who wished for general and philosophical notions only, and not sufficiently precise and demonstrative for the few, who wanted practical and numerical results. In attempting to combine the separate merits of the *Exposition du Systeme du Monde*, and of the *Mécanique Céleste*, the author sacrificed both the popular simplicity of the former, and the mathematical perfection of the latter. A few inaccuracies, which ought not to escape the attention of the reader of the work, have been pointed out in the *Imperial Review* for March 1805; a journal long since discontinued.

7. The contents of the volume last mentioned, together with some manuscripts intended to have formed part of a second, and the greater part of the articles furnished by Professor Robison to the *Encyclopædia*, were collected into a *System of Mechanical Philosophy, with Notes*, by David Brewster, LL.D. 4 vols. 8. Ed. 1822; a spirited bookseller in London having undertaken the risk of the publication. 1. The first volume begins with the articles Dynamics, Projectiles, Corpuscular Forces, Capillary Attraction, Boscovich's Theory, and Rotation, all as remodelled for the *Elements*: then follow Strength of Materials, Carpentry, Roof, Construction of Arches, Construction of Centres. 2. The article Steam-Engine is enriched with notes and an appendix, by the late Mr Watt; the next is Machinery; then Resistance of Fluids, Rivers, Waterworks, Pumps. 3. Astronomy, Telescope, Pneumatics. 4. Electricity, Magnetism, Variation, Temperament, Trumpet, Watchwork, and Seamanship. The notes are not numerous, and the editor's principal labour has been to retrench some passages that appeared to him superfluous, when the papers were to stand as parts of such a collection.

"Although Dr Robison's name," says Dr Brewster in his preface, "cannot be associated with the great discoveries of the century which he adorned, yet the memory of his talents and his virtues will be long cherished by his country. Imbued with the genuine spirit of the philosophy which he taught, he was one of the warmest patrons of genius wherever it was found. His mind was nobly elevated above the mean jealousies of rival ambition, and his love of science and of justice was too ardent to allow him either to depreciate the labours of others, or to transfer them to himself. To these great qualities as a philosopher, Dr Robison added all the more estimable endowments of domestic and of social life. His friendship was at all times generous and sincere. His piety was ardent and unostentatious. His patriotism was of the most pure and exalted character; and, like the immortal Newton, whose memory he cherished with a peculiar reverence, he was preeminently entitled to the high distinction of a Christian, patriot, and philosopher." His person was handsome, and his physiognomy prepossessing; and he appears to have been endowed with an extraordinary combination of talents, even exclusively of those which were called into immediate activity in his professional pursuits; for he was a good linguist, an excellent draughtsman, and an accomplished musician: his conversation was always energetic and interesting, and sometimes even poetical; and his liberality of sentiment was only limited by his regard for what he considered as the best interests of mankind.

A short account of his life was published in 1802, by a contributor to the *Philosophical Magazine*, who, among other inaccuracies, thought himself at liberty to assert that he was an admirer of the algebraical form of representation, in preference to the geometrical. His friend, Dr Gleig, stepped forwards soon after to correct these mistakes, in the *Antijacobin Review* for 1802, and his letter was copied into the *Philosophical Magazine*. He asserts, from his own knowledge, that even yet Professor Robison "delights much more in geometry than in any of the modes of algebra, assigning, as the reason of his preference, that in the longest demonstration, the geometrician has al-

ways clear and adequate ideas, which the most expert algebraist can very seldom have." It may perhaps be asserted, on the other hand, that the same reasoning would lead us always to employ actual multiplication or division, in preference to the use of logarithms or of a sliding rule ; and that the whole of the magic of calculation depends on the abstraction of the results from the numerous and separately unimportant steps by which they are obtained : but the having once seen those steps clearly is certainly of great importance to the process of reasoning, even when the memory no longer retains them ; and no mathematician of correct taste can study the ancient geometricians without admiring the elegance and precision of their method, even amidst the pedantry which too frequently envelopes their expressions, and without being grateful for their punctuality in collecting their results into the very convenient form of distinct propositions, and in making such references from each proposition to the foundations on which it depends, as to enable him readily to trace back their steps to the most elementary principles ; which is scarcely possible in any of the works of the most modern school of analysis. Professor Robison, however, seems rarely to have cultivated the higher mathematics for their own sake only, or any further than as they could be applied to the study of the phenomena of nature, or to the practice of the combinations of art; in fact, without some such limitation, there would be no track to guide us in the pathless regions of quantity and number, and their endless relations and functions. But besides the utility of the pure mathematics, as a branch of early education, in exercising and fortifying the powers of the mind, it is impossible to foresee with certainty *how much* of mathematics may be wanted by the natural philosopher in any given investigation ; and Professor Robison, as well as many others of his countrymen, would certainly have been the better for the possession of *a little more*, as the author of the criticisms in the *Imperial Review* has already had occasion to remark.

[*Phil. Mag.* XIII. Dr Gleig, in *Antijacobin Mag.* XI. 1802. Stark's *Biographia Scotica.* Aikin's *General Biography,* VIII. 4. Lond. 1813. Playfair, in *Ed. Trans.* VII. 1815, p. 495. Chalmers's *Biographical Dictionary,* XXV. 8vo. Lond. 1816.]

(A. L.)

ROMANCE.

Definition and origin of the word Romance.

DR JOHNSON has defined Romance, in its primary sense, to be " a military fable of the middle ages ; a tale of wild adventures in love and chivalry." But although this definition expresses correctly the ordinary idea of the word, it is not sufficiently comprehensive to answer our present purpose. A composition may be a legitimate romance, yet neither refer to love nor chivalry—to war nor to the middle ages. The " wild adventures" is almost the only absolutely essential ingredient in Johnson's definition. We would be rather inclined to describe a *Romance* as " a fictitious narrative in prose or verse; the interest of which turns upon marvellous and uncommon incidents ;" being thus opposed to the kindred term *Novel,* which Johnson has described as " a smooth tale, generally of love ;" but which we would rather define as " a fictitious narrative, differing from the romance, because accommodated to the ordinary train of human events, and the modern state of society." Assuming these definitions, it is evident, from the nature of the distinction adopted, that there may exist compositions which it is difficult to assign precisely or exclusively to the one class or other ; and which, in fact, partake of the nature of both. But the distinction will be found broad enough to answer all general and useful purposes.

The word Romance, in its original meaning, was far from corresponding with the definition now assigned. On the contrary, it signified merely one or other of the popular dialects of Europe, founded (as almost all these dialects were) upon the Roman tongue, that is, upon the Latin. The name of romance was indiscriminately given to the Italian, to the Spanish, even (in one remarkable instance at least)* to the English language. But it was especially applied to the compound language of France ; in which the Gothic dialect of the Franks, the Celtic of the ancient Gauls, and the classical Latin, formed the ingredients. Thus Robert De Brunne :

" All is calde geste Inglis,
That en this language spoken is—
Frankis speech is caled *Romance,*
So sayis clerkis and men of France."

At a period so early as 1150, it plainly appears that the Romance Language was distinguished from the Latin, and that translations were made from the one into the other ; for an ancient romance on the subject of Alexander, quoted by Fauchet, says it was written by a learned clerk,

" Qui *de Latin* la trest, et *en Roman* la mit."

The most noted romances of the middle ages were usually composed in the romance or French lan-

* This curious passage was detected by the industry of Ritson in *Giraldus Cambrensis,* " *Ab aquâ illa optima, quæ Scottice vocata est* FROTH ; *Brittanice,* WEIRD ; Romane vero *Scotte-Wattre.*" Here the various names assigned to the Frith of Forth are given in the Gaelic or Earse, the British or Welsh ; and the phrase *Roman* is applied to the ordinary language of England. But it would be difficult to show another instance of the English language being termed Roman or Romance.

guage, which was, in a peculiar degree, the speech of love and chivalry; and those which are written in English always affect to refer to some French original, which usually, at least, if not in all instances, must be supposed to have a real existence. Hence the frequent recurrence of the phrase,

> "As in romance we read;"

Or,

> "Right as the romaunt us tells;"

and equivalent phrases, well known to all who have at any time perused such compositions. Thus, very naturally, though, undoubtedly, by slow degrees, the very name of romaunt, or romance, came to be transferred from the language itself to that peculiar style of composition in which it was so much employed, and which so commonly referred to it. How early, a transference so natural took place, we have no exact means of knowing; but the best authority assures us, that the word was used in its modern sense so early as the reign of Edward III. Chaucer, unable to sleep during the night, informs us, that, in order to pass the time,

> "Upon my bed I sate upright;
> A ROMAUNCE, and he me it took
> To read and drive the night away."

The book described as a romance contained, as we are informed,

> "———— Fables
> That clerkis had, in old time,
> And other poets, put in rhyme."

And the author tells us, a little lower,

> "This book ne spake but of such things,
> Of Queens' lives and of Kings."

The volume proves to be no other than Ovid's *Metamorphosis;* and Chaucer, by applying to it the name of romance, sufficiently establishes that the word was, in his time, correctly employed under the modern acceptation.

Having thus accounted for the derivation of the word, our investigation divides itself into three principal branches, though of unequal extent. In the FIRST of these we propose to inquire into the general History and Origin of this peculiar species of composition, and particularly of Romances relating to European Chivalry, which necessarily form the most interesting object of our inquiry; and in the SECOND, to give some brief account of the History of the Romance of Chivalry in the different states of Europe. THIRDLY, We propose to notice cursorily the various kinds of Romantic Composition by which the ancient romances of chivalry were followed and superseded, and with these notices to conclude the article.

General History of Romance.

I. In the views taken by Hurd, Percy, and other older authorities, of the origin and history of romantic fiction, their attentions were so exclusively fixed upon the romance of chivalry alone, that they seem to have forgotten that, however interesting and peculiar, it formed only one species of a very numerous and extensive genus. The progress of romance, in fact, keeps pace with that of society, which cannot long exist, even in the simplest state, without exhibiting some specimens of this attractive style of composition. It is not meant by this assertion, that in early ages such narratives were invented, in the character of mere fictions, devised to pass away the leisure of those who have time enough to read and attend to them. On the contrary, romance and real history have the same common origin. It is the aim of the former to maintain as long as possible the mask of veracity; and indeed the traditional memorials of all earlier ages partake in such a varied and doubtful degree of the qualities essential to those opposite lines of composition, that they form a mixed class between them; and may be termed either romantic histories, or historical romances, according to the proportion in which their truth is debased by fiction, or their fiction mingled with truth.

A moment's glance at the origin of society will satisfy the reader why this can hardly be otherwise. The father of an isolated family, destined one day to rise from thence into a nation, may, indeed, narrate to his descendants the circumstances which detached him from the society of his brethren, and drove him to form a solitary settlement in the wilderness, with no other deviation from truth, on the part of the narrator, than arises from the infidelity of memory, or the exaggerations of vanity. But when the tale of the patriarch is related by his children, and again by his descendants of the third and fourth generation, the facts it contains are apt to assume a very different aspect. The vanity of the tribe augments the simple annals from one cause—the love of the marvellous, so natural to the human mind, contributes its means of sophistication from another—while, sometimes, the king and the priest find their interest in casting a holy and sacred gloom and mystery over the early period in which their power arose. And thus altered and sophisticated from so many different motives, the real adventures of the founder of the tribe bear as little proportion to the legend recited among his children, as the famous hut of Loretto bears to the highly ornamented church with which superstition has surrounded and enchased it. Thus the definition which we have given of Romance as a fictitious narrative turning upon the marvellous or the supernatural, might, in a large sense, be said to embrace

> ———— quicquid Græcia mendax
> Audet in historia,

or, in fine, the mythological and fabulous history of all early nations.

It is also important to remark, that poetry, or rather verse—rythm at least of some sort or other, is originally selected as the best vehicle for these traditional histories. Its principal recommendation is probably the greater facility with which metrical narratives are retained in the memory—a point of the last consequence, until the art of writing is generally introduced; since the construction of the verse itself forms an artificial association with the sense, the one of which seldom fails to recal the other to recollection. But the medium of verse, at first adopted

merely to aid the memory, becomes soon valuable on account of its other qualities. The march or measure of the stanza is gratifying to the ear, and, like a natural strain of melody, can be restrained or accelerated, so as to correspond with the tone of feeling which the words convey; while the recurrence of the necessary measure rythm, or rhyme, is perpetually gratifying the hearer by a sense of difficulty overcome. Verse being thus adopted as the vehicle of traditional history, there needs but the existence of a single man of genius, in order to carry the composition a step higher in the scale of literature than that of which we are treating. In proportion to the skill which he attains in his art, the fancy and ingenuity of the artist himself are excited; the simple narrative transmitted to him by ruder rhymers is increased in length; is decorated with the graces of language, amplified in detail, and rendered interesting by description; until the brief and barren original bears as little resemblance to the finished piece, as the *Iliad* of Homer to the evanescent traditions, out of which the blind bard wove his tale of Troy Divine. Hence the opinion expressed by the ingenious Percy, and assented to by Ritson himself. When about to present to his readers an excellent analysis of the old romance of *Lybius Disconius*, and making several remarks on the artificial management of the story, the Bishop observes, that "if an Epic poem may be defined a fable related by a poet to excite admiration and inspire virtue, by representing the action of some one hero favoured by Heaven, who executes a great design in spite of all the obstacles that oppose him, I know not why we should withhold the name of *Epic Poem* from the piece which I am about to analyse."*

Yet although this levelling proposition has been laid down by Percy, and assented to by Ritson (writers who have few opinions in common), and although, upon so general a view of the subject, the *Iliad*, or even the *Odyssey*, of Homer might be degraded into the class of romances, as *Le Beau Deconnu* is elevated into that of epic poems, there lies in ordinary speech, and in common sense, as wide a distinction between these two classes of composition, as there is betwixt the rude mystery or morality of the middle ages, and the regular drama by which these were succeeded. Where the art and the ornaments of the poet chiefly attract our attention—where each part of the narrative bears a due proportion to the others, and the whole draws gradually towards a final and satisfactory conclusion—where the characters are sketched with force, and sustained with precision—where the narrative is enlivened and adorned with so much, and no more, of poetical ornament and description, as may adorn, without impeding its progress—where this art and taste is displayed, supported, at the same time, by a sufficient tone of genius, and art of composition, the work produced must be termed an Epic Poem, and the author may claim his seat upon the high and honoured seat occupied by Homer, Virgil, and Milton. On the other hand, when a story languishes in tedious and minute details, and relies for the interest which it proposes to excite, rather upon the wild excursions of an unbridled fancy, than upon the skill of the poet—when the supernatural and the extraordinary are relied upon exclusively as the supports of the interest, the author, though his production may be distinguished by occasional flashes of genius, and though it may be interesting to the historian, as containing some minute fragments of real events, and still more so to the antiquary, from the light which it throws upon ancient manners, is still no more than a humble Romancer, and his work must rank amongst those rude ornaments of a dark age, which are at present the subject of our consideration. Betwixt the extremes of the two classes of composition, there must, no doubt, exist many works, which partake in some degree of the character of both; and after having assigned most of them each to their proper class, according as they are distinguished by regularity of composition and poetical talent, or, on the contrary, by extravagance of imagination, and irregularity of detail, there may still remain some, in which these properties are so equally balanced, that it may be difficult to say to which class they belong. But although this may be the case in a very few instances, our taste and habits readily acknowledge as complete and absolute a difference betwixt the Epopeia and Romance, as can exist betwixt two distinct species of the same generic class.

We have said of romance, that it first appears in the form of metrical history, professes to be a narrative of real facts, and is, indeed, nearly allied to such history as an early state of society affords; which is always exaggerated by the prejudices and partialities of the tribe to which it belongs, as well as deeply marked by their idolatry and superstition. These it becomes the trade of the romancers still more to exaggerate, until the thread of truth can scarce be discerned in the web of fable which involves it; and we are compelled to renounce all hope of deriving serious or authentic information from the materials upon which the compounders of fiction have been so long at work, from one generation to another, that they have at length obliterated the very shadow of reality or even probability.

The view we have given of the origin of romance will be found to agree with the facts which the researches of so many active investigators of this curious subject have been able to ascertain. It is found, for example, and we will produce instances in viewing the progress of romance in particular countries, that the earliest productions of this sort, known to exist, are short narrations or ballads, which were probably sung on solemn or festival occasions, recording the deeds and praises of some famed champion of the tribe and country, or perhaps the history of some remarkable victory or signal defeat, calculated to interest the audience by the associations

* *Reliques of Ancient English Poetry*, III. xxvii. The Prelate is citing a discourse on epic poetry, prefixed to *Telemachus*.

Romance.

which the song awakens. These poems, of which very few can now be supposed to exist, are not without flashes of genius, but brief, rude, and often obscure, from real antiquity or affected sublimity of diction. The song on the battle of Brunanburgh, preserved in the *Saxon Chronicle*, is a genuine and curious example of this aboriginal style of poetry.

Temporal and Spiritual Romances.

Even at this early period, * there may be observed a distinction betwixt what may be called the *Temporal* and *Spiritual* romances; the first destined to the celebration of worldly glory,—the second to recording the deaths of martyrs and the miracles of saints; both which themes unquestionably met with an almost equally favourable reception from their hearers. But although most nations possess, in their early species of literature, specimens of both kinds of romance, the proportion of each, as was naturally to have been expected, differs according as the genius of the people amongst whom they occur leaned towards devotion or military enterprise. Thus, of the Saxon specimens of poetry, which manuscripts still afford us, a very large proportion is devotional, amongst which are several examples of the spiritual romance, but very few, indeed, of those respecting warfare or chivalry. On the other hand, the Norman language, though rich in examples of both kinds of romances, is particularly abundant in that which relates to battle and warlike adventure. The Christian Saxons had become comparatively pacific, while the Normans were certainly accounted the most martial people in Europe.

However different the spiritual romance may be from the temporal in scope and tendency, the nature of the two compositions did not otherwise greatly differ. The structure of verse and style of composition was the same; and the induction, even when the most serious subject was undertaken, exactly resembled that with which minstrels introduced their idle tales, and often contained allusions to them. Warton quotes a poem on the Passions, which begins,

I hereth one lutele tale, that Ich eu wille telle,
As wi vyndeth hit invrite in the godspelle,
Nuz hit nouht of Carlemeyne ne of the Duzpere,
Ac of Criste's thruurynge, &c.

The temporal romances, on the other hand, often commenced by such invocations of the Deity, as would only have been in place when a much more solemn subject was to be agitated. The exordium of the Romance of *Ferumbras* may serve as an example of a custom almost universal:

God in glorye of mightis moost
That all things made in sapience,
By virtue of Word and Holy Gooste,
Giving to men great excellence, &c.

The distresses and dangers which the knight endured for the sake of obtaining earthly fame and his mistress's favour, the saint or martyr was exposed to for the purpose of securing his rank in heaven, and the favour of some beloved and peculiar patron saint. If the earthly champion is in peril from monsters, dragons, and enchantments, the spiritual hero is represented as liable to the constant assaults of the whole invisible world, headed by the ancient dragon himself. If the knight is succoured at need by some favouring fairy or protecting genius, the saint is under the protection not only of the whole heavenly host, but of some one divine patron or patroness who is his especial auxiliary. Lastly, the conclusion of the romance, which usually assigns to the champion a fair realm, an abundant succession, and a train of happy years, consigns to the martyr his fane and altar upon earth, and in heaven his seat among saints and angels, and his share in a blessed eternity. It remains but to say, that the style and language of these two classes do not greatly differ, and that the composers of both employ the same structure of rythm and of language, and draw their ideas and their incidents from similar sources; so that, having noticed the existence of the spiritual romance, it is unnecessary for the present to prosecute this subject farther.

Comic Romances.

Another early and natural division of these works of fiction seems to have arranged them into *Serious* and *Comical*. The former were by far the most numerous, and examples of the latter are in most countries comparatively rare. Such a class, however, existed, as proper romances, even if we hold the comic romance distinct from the *Contes* and *Fabliaux* of the French, and from such jocular English narratives as the *Wife Lapt in Moril's Skin, The Friar and the Boy*, and similar humorous tales; of which the reader will find many examples in Ritson's *Ancient English Poetry*, and in other collections. The scene of these *gestes* being laid in low, or at least in ordinary life, they approach in their nature more nearly to the class of novels, and may perhaps be considered as the earliest specimens of that kind of composition. But the proper comic romance was that in which the high terms and knightly adventures of chivalry were burlesqued, by ascribing them to clowns or others of a low and mean degree. They formed, as it were, a parody on the serious romance, to which they bore the same proportion as the antimasque, studiously filled with grotesque, absurd, and extravagant characters, "entering," as the stage direction usually informs us, "to a confused music," bore to the masque itself, where all was dignified, noble, stately, and harmonious.

An excellent example of the comic romance is the *Tournament of Tottenham*, printed in Percy's *Reliques*, in which a number of clowns are introduced practising one of these warlike games, which were the exclusive prerogative of the warlike and noble. They are represented making vows to the swan, the peacock, and the ladies; riding a tilt on their clumsy cart horses, and encountering each other with ploughshares and flails; while their defensive armour consisted of great wooden bowls and troughs, by way of helmets

* The religious romances of *Barlaam* and *Jehosaphat* were composed by John of Damascus in the eighth century.

omance. and cuirasses. The learned editor seems to have thought this singular composition was like Don Quixote, with which he compares it, a premeditated effort of satire, written to expose the grave and fantastic manners of the serious romance. This is considering the matter too deeply, and ascribing to the author a more critical purpose than he was probably capable of conceiving. It is more natural to suppose that his only ambition was to raise a laugh, by ascribing to the vulgar the manners and exercises of the noble and valiant; as in the well known farce of *High Life Below Stairs,* the ridicule is not directed against the manners described, but against the menials who affect those that are only befitting their superiors. The *Hunting of the Hare,* published in the collection formed by the late industrious and accurate Mr Weber, is a comic romance of the same order. A yeoman informs the inhabitants of a country hamlet that he has found a hare sitting, and invites them to come to course her. They attend, accordingly, with all the curs and mastiffs of their village, and the unsportsmanlike manner in which the inexperienced huntsmen and their irregular pack conduct themselves, forms the interest of the piece. It can hardly be supposed the satire is directed against the sport of hunting itself; since the whole ridicule arises out of the want of the necessary knowledge of its rules, incident to the ignorance and inexperience of the clowns who undertook to practise an art peculiar to gentlemen. The ancient poetry of Scotland furnishes several examples of this ludicrous style of romantic composition; as the *Tournament at the Drum,* and the *Justing of Watson and Barbour,* by Sir David Lindsay. It is probable that these mock encounters were sometimes acted in earnest; at least King James I. is accused of witnessing such practical jests; " sometimes presenting David Droman and Archie Armstrong, the king's fool, on the back of other fools, to tilt at one another till they fell together by the ears."—(Sir Antony Weldon's *Court of King James.*)

lassical Romances.

In hastily noticing the various divisions of the romance, we have in some degree delayed our promised account of its rise and progress; an inquiry which we mean chiefly to confine to the romance of the middle ages. For, although it be true that this species of composition is common to almost all nations, and that even if we deem the *Iliad* and *Odyssey* compositions too dignified by the strain of poetry in which they are composed to bear the name of metrical romances; yet we have the pastoral romance of *Daphnis and Chloe,* and the historical romance of *Theagenes and Churiclea,* which are sufficiently accurate specimens of that style of composition to which it is probable the *Milesian fables* and the romances of Antonius Diogenes, described by Photius, could they be recovered, would also be found to belong. It is impossible to avoid noticing that the Sybarites, whose luxurious habits seem to have been intellectual, as well as sensual, were peculiarly addicted to the perusal of the Milesian fables; from which we may conclude that they were not of that severe kind which inspired high thoughts and martial virtues. But there would be little advantage derived from extending our researches into the ages of classical antiquity respecting a class of compositions which, though they existed then, as in almost every stage of society, were neither so numerous nor of such high repute as to constitute any considerable portion of their literature. Romance.

Eastern Romances.

Want of space also may entitle us to dismiss the consideration of the Oriental romances, unless in so far as in the course of the middle ages they came to furnish materials for enlarging and varying the character of the romances of knight-errantry. That they existed early, and were highly esteemed both among the Persians and Arabians, has never been disputed; and the most interesting light has been lately thrown on the subject by the publication of *Antar,* one of the most ancient, as well as most rational, if we may use the phrase, of the Oriental fictions. The Persian romance of the *Sha-Nameh* is well known to Europeans by name, and by copious extracts; and the love-tale of *Mejnoun and Leilah* is also familiar to our ears, if not to our recollections. Many of the fictions in the extraordinary collection of the *Arabian Tales* approach strictly to the character of romances of chivalry; although in general they must be allowed to exceed the more tame northern fictions in dauntless vivacity of invention, and in their more strong tendency to the marvellous. Several specimens of the comic romance are also to be found mingled with those which are serious; and we have the best and most positive authority that the recital of these seductive fictions is at this moment an amusement as fascinating and general among the people of the East, as the perusal of printed romances and novels among the European public. But a minute investigation into this particular species of romance would lead us from our present field, already sufficiently extensive for the limits to which our plan confines it.

Romances of Chivalry.

The European Romance, wherever it arises, and in whatsoever country it begins to be cultivated, had its origin in some part of the real or fabulous history of that country; and of this we will produce, in the sequel, abundant proofs. But the simple tale of tradition had not passed through many mouths, ere some one, to indulge his own propensity for the wonderful, or to secure by novelty the attention of his audience, augments the meagre chronicle with his own apocryphal inventions. Skirmishes are magnified into great battles; the champion of a remote age is exaggerated into a sort of demi-god; and the enemies whom he encountered and subdued are multiplied in number, and magnified in strength, in order to add dignity to his successes against them. Chaunted to rythmical numbers, the songs which celebrate the early valour of the fathers of the tribe become its war-cry in battle, and men march to conflict hymning the praises and the deeds of some real or supposed precursor who had marshalled their fathers in the path of victory. No reader can have forgotten that when the decisive battle of Hastings commenced, a Norman minstrel, Taillefer, advanced on horseback before the invading host, and gave the signal for onset, by singing the *Song of Roland,* that renowned nephew of Charlemagne, of whom romance speaks so much, and history so little; and whose fall, with the chivalry of Charles the Great in the pass of Roncesvalles, has given rise to such clouds of ro-

Romance.

mantic fiction, that its very name has been for ever associated with it. The remarkable passage has been often quoted from the *Brut of Wace*, an Anglo-Norman metrical chronicle.

> Taillefer, qui moult bien chantont
> Sur un cheval gi tost alont,
> Devant le Duc alont chantant
> De Karlemaigne et de Rollant,
> Et d'Oliver et des vassals,
> Qui morurent en Rencevals.

Which may be thus rendered,

> Taillefer, who sung both well and loud,
> Came mounted on a courser proud;
> Before the Duke the minstrel sprung,
> And loud of Charles and Roland sung,
> Of Oliver and champions mo,
> Who died at fatal Ronçevaux.

This champion possessed the sleight-of-hand of the juggler, as well as the art of the minstrel. He tossed up his sword in the air, and caught it again as he galloped to the charge, and showed other feats of dexterity. Taillefer slew two Saxon warriors of distinction, and was himself killed by a third. Ritson, with less than his usual severe accuracy, supposed that Taillefer sung some part of a long metrical romance upon Roland and his history; but the words *chanson, cantilena*, and *song*, by which the composition is usually described, seems rather to apply to a brief ballad or national song; which is also more consonant with our ideas of the time and place where it was chaunted.

But neither with these romantic and metrical chronicles did the mind long remain satisfied; more details were demanded, and were liberally added by the invention of those who undertook to cater for the public taste in such matters. The same names of kings and champions, which had first caught the national ear, were still retained, in order to secure attention, and the same assertions of authenticity, and of reference to real history, were stoutly made both in the commencement and in the course of the narrative. Each nation, as will presently be seen, came to adopt to itself a cycle of heroes like those of the *Iliad;* a sort of common property to all minstrels who chose to make use of them, under the condition always that the general character ascribed to each individual hero was preserved with some degree of consistency. Thus, in the romances of *The Round Table*, Gawain is uniformly represented as courteous; Kay as rude and boastful; Mordred as treacherous; and Sir Launcelot as a true though a sinful lover, and in all other respects a model of chivalry. Amid the Paladins of Charlemagne, whose cycle may be considered as peculiarly the property of French in opposition to Norman-Anglo romance, Gan, or Ganelon of Mayence, is represented as uniformly faithless, and engaged in intrigues for the destruction of Christianity; Roland as brave, unsuspicious, devotedly loyal, and somewhat simple in his disposition; Renaud, or Rinaldo, is painted with all the properties of a borderer, valiant, alert, ingenious, rapacious, and unscrupulous. The same conventional distinctions may be traced in the history of the Nibelung, which has supplied matter for so many Teutonic adventurers. Meister Hildebrand, Etzel, Theodorick, and the champion Hogan, as well as Chrimhelda and the females introduced, have the same individuality of character, which is ascribed, in Homer's immortal writings, to the wise Ulysses, the brave but relentless Achilles, his more gentle friend Patroclus, Sarpedon, the favourite of the gods, and Hector, the protector of mankind. It was not permitted to the invention of a Greek poet to make Ajax a dwarf, or Teucer a giant, Thersites a hero, or Diomedes a coward; and it seems to have been under similar restrictions respecting consistency that the ancient romancers exercised their ingenuity upon the materials supplied them by their predecessors. But, in other respects, the whole store of romantic history and tradition was free to all as a joint stock in trade, on which each had a right to draw as suited his particular purposes. He was at liberty not only to select a hero out of known and established names which had been the theme of others, but to imagine a new personage of his own pure fancy, and combine him with the heroes of Arthur's Table or Charlemagne's Court, in the way which best suited his fancy. He was permitted to excite new wars against those bulwarks of Christendom, invade them with fresh and innumerable hosts of Saracens, reduce them to the last extremity, drive them from their thrones, and lead them into captivity, and again to relieve their persons, and restore their sovereignty, by events and agents totally unknown in their former story.

In the characters thus assigned to the individual characters of romantic fiction, it is possible there might be some slight foundation in remote tradition, as there were also probably some real grounds for the existence of such persons, and perhaps for a very few of the leading circumstances attributed to them. But these realities only exist as the few grains of wheat in the bushel of chaff, incapable of being winnowed out, or cleared from the mass of fiction with which each new romancer had in his turn overwhelmed them. So that romance, though certainly deriving its first original from the pure font of History, is supplied, during the course of a very few generations, with so many tributes from the Imagination, that at length the very name comes to be used to distinguish works of pure fiction.

When so popular a department of poetry has attained this decided character, it becomes time to inquire who were the composers of these numerous, lengthened, and once admired narratives which are called metrical romances, and from whence they drew their authority. Both these subjects of discussion have been the source of great controversy among antiquarians; a class of men who, be it said with their forgiveness, are apt to be both positive and polemical upon the very points which are least susceptible of proof, and which are least valuable if the truth could be ascertained; and which, therefore, we would gladly have seen handled with more diffidence, and better temper in proportion to their uncertainty.

The Minstrels.

The late venerable Dr Percy, Bishop of Dromore,

led the way unwarily to this dire controversy, by ascribing the composition of our ancient heroic songs and metrical legends, in rather too liberal language, to the minstrels, that class of men by whom they were generally recited. This excellent person, to whose memory the lovers of our ancient lyre must always remain so deeply indebted, did not, on publishing his work nearly fifty years ago, see the rigid necessity of observing the utmost and most accurate precision either in his transcripts or his definitions. The study which he wished to introduce was a new one—it was his object to place it before the public in an engaging and interesting form; and, in consideration of his having obtained this important point, we ought to make every allowance, not only for slight inaccuracies, but for some hasty conclusions, and even exaggerations, with which he was induced to garnish his labour of love. He defined the minstrels, to whose labours he chiefly ascribed the metrical compositions on which he desired to fix the attention of the public, as "an order of men in the middle ages, who subsisted by the arts of poetry and music, and sung to the harp verses composed by themselves or others."* In a very learned and elegant essay upon the text thus announced, the reverend Prelate in a great measure supported the definition which he had laid down; although it may be thought that, in the first editions at least, he has been anxious to view the profession of the minstrels on their fairest and most brilliant side; and to assign to them a higher station in society than a general review of all the passages connected with them will permit us to give to a class of persons who either lived a vagrant life, dependent on the precarious taste of the public for a hard-earned maintenance, or, at best, were retained as a part of the menial retinue of some haughty baron, and in a great measure identified with his musical band.

The late acute, industrious, and ingenious Mr Joseph Ritson, whose severe accuracy was connected with an unhappy eagerness and irritability of temper, took advantage of the exaggerations occasionally to be found in the Bishop's *Account of Ancient Minstrelsy*, and assailed him with terms which may be termed any thing but courteous. Without finding an excuse either in the novelty of the studies in which Percy had led the way, or in the vivacity of imagination which he did not himself share, he proceeded to arraign each trivial inaccuracy as a gross fraud, and every deduction which he considered to be erroneous as a wilful untruth, fit to be stigmatized with the broadest appellation by which falsehood can be distinguished. Yet there is so little room for this extreme loss of temper, that, upon a recent perusal of both these ingenious essays, we were surprised to find that the reverend Editor of the *Reliques*, and accurate Antiquary, have differed so very little as, in essential facts, they appear to have done. Quotations are, indeed, made by both with no sparing hand, and hot arguments; and, on one side at least, hard words are unsparingly employed; while, as is said to happen in theological polemics, the contest grows warmer in proportion as the ground concerning which it is carried on is narrower and more insignificant. In reality, their systems do not essentially differ.

Ritson is chiefly offended at the sweeping conclusion in which Percy states the minstrels as subsisting by the arts of poetry and music, and reciting to the harp verses composed by themselves and others. He shows very successfully that this definition is considerably too extensive, and that the term minstrel comprehended, of old, not merely those who recited to the harp or other instrument romances and ballads, but others who were distinguished by their skill in instrumental music only; and, moreover, that jugglers, sleight-of-hand performers, dancers, tumblers, and such like subordinate artists who were introduced to help away the tedious hours in an ancient feudal castle, were also comprehended under the general term of minstrel. But although he distinctly proves that Percy's definition applied only to one class of the persons termed minstrels, those namely who sung or recited verses, and in many cases of their own composition; the bishop's position remains unassailable, in so far as relates to one general class, and these the most distinguished during the middle ages. All minstrels did not use the harp, and recite or compose romantic poetry; but it cannot be denied that such was the occupation of the most eminent of the order. This Ritson has rather admitted than denied; and the number of quotations which his industry has brought together, rendered such an admission inevitable.

Indeed, the slightest acquaintance with ancient romances of the metrical class, shows us that they were composed for the express purpose of being recited, or, more properly, chaunted to some simple tune or cadence for the amusement of a large audience. Our ancestors, as they were circumscribed in knowledge, were also more limited in conversation than their enlightened descendants; and it seems probable, that, in their public festivals, there was great advantage found in the presence of a minstrel who should recite some popular composition on their favourite subjects of love and war, to prevent those pauses of conversation which sometimes fall heavily on a company, even of the present accomplished age, and to supply an agreeable train of ideas to those guests who had none of their own. It is, therefore, almost constantly insinuated, that the romance was to be chaunted or recited to a large and festive society, and in some part or other of the piece, generally at the opening, there is a request of attention on the part of the performer; and hence, the perpetual "Lythe and listen lordings free," which in those, or equivalent words, forms the introduction to so many romances. As, for example, in the old poem of *Guy and Colbrand*, the minstrel speaks of his own occupation:

* *Essay on Ancient Minstrels in England*, prefixed to the first volume of Bishop Percy's *Reliques*.

> "When meat and drink is great plentye,
> Then lords and ladyes still will be,
> And sit and solace lythe.
> Then it is time for mee to speake,
> Of kern knights and kempes greate,
> Such carping for to kythe."

Chaucer, also, in his Ryme of Sir Thopas, assigns to the minstrels of his hero's household the same duty of reciting romances of spiritual or secular heroes, for the good knight's pastime while arming himself for battle:

> "Do cum," he sayed, "my minestrales,
> And jestours for to tellen tales
> Anon in min arming,
> Of romaunces that ben reales,
> Of popes and of cardinales,
> And eke of love-longing."

Not to multiply quotations, we will only add one of some importance, which must have escaped Ritson's researches; for his editorial integrity was such, as rendered him incapable of suppressing evidence on either side of the question. In the old romance or legend of *True Thomas and the Queen of Elfland*, Thomas the Rhymer, himself a minstrel, is gifted by the Queen of the Faery with the faculties of music and song. The answer of Thomas is not only conclusive as to the minstrel's custom of recitation, but shows that it was esteemed the highest branch of his profession, and superior as such to mere instrumental music:

> "To harp and carp Thomas wheresover ye gon,
> Thomas take the these with the"——
> "Harping," he said, "ken I non,
> For tong is chefe of Mynstralse." *

We, therefore, arrive at the legitimate conclusion, that although, under the general term minstrels, were comprehended many who probably entertained the public only with instrumental performances, with ribald tales, with jugglery, or farcical representations, yet one class amongst them, and that a numerous one, made poetical recitation their chief, if not their exclusive occupation. The memory of these men were, in the general case, the depository of the pieces which they recited; and hence, although many of their romances still survive, very many more have doubtless fallen into oblivion.

That the minstrels were also the authors of many of these poems, and that they altered and enlarged others, is a matter which can scarce be doubted, when it is proved that they were the ordinary reciters of them. It was as natural for a minstrel to become a poet or composer of romances, as for a player to be a dramatic author, or a musician a composer of music. Whosoever, among a class, whose trade it was to recite poetry, felt the least degree of taste or enthusiasm in a profession so peculiarly calculated to inspire it, must, from that very impulse, have become an original author, or translator at least; thus giving novelty to his recitations, and acquiring additional profit and fame. Bishop Percy, therefore, states the case fairly in the following passage: "It can hardly be expected that we should be able to produce regular and unbroken annals of the minstrel art and its professors, or have sufficient information, whether every minstrel or bard composed himself, or only repeated, the songs he chaunted. Some probably did the one and some the other; and it would have been wonderful, indeed, if men, whose peculiar profession it was, and who devoted their time and talents to entertain their hearers with poetical compositions, were peculiarly deprived of all poetical genius themselves, and had been under a physical incapacity of composing those common popular rhymes, which were the usual subjects of their recitation." † While, however, we acquiesce in the proposition, that the minstrels composed many, perhaps the greater part of the metrical romances which they sung, it is evident they were frequently assisted in the task by others who, though not belonging to this profession, were prompted by leisure and inclination to enter upon the literary or poetical department as amateurs. These very often belonged to the clerical profession, amongst whom relaxation of discipline, abundance of spare time, and impatience of the routine of ceremonious duties often led individuals into worse occupations than the listening to or composing metrical romances. It was in vain that both the poems and the minstrels who recited them were, by statute, debarred from entering the more rigid monasteries. Both found their way frequently to the refectory, and were made more welcome than brethren of their own profession; as we may learn from a memorable *Gest*, in which two poor travelling priests, who had been received into a monastery with acclamation, under the mistaken idea of their being minstrels, are turned out in disgrace, when it is discovered that they were indeed capable of furnishing spiritual instruction, but understood none of the entertaining arts with which the hospitality of their convent might have been repaid by itinerant bards.

Nay, besides a truant disposition to a forbidden task, many of the grave authors may have alleged, in their own defence, that the connection between history and romance was not in their day entirely dissolved. Some eminent men exercised themselves in both kinds of composition; as, for example,

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* Jamieson's *Popular Ballads*, Vol. II. p. 27.

† *Essay on the Ancient Minstrels*, p. 30.

Another authority of ancient date, the *Chronicle* of Bertrand Guesclin, distinctly attributes the most renowned romances to the composition of the minstrels by whom they were sung. As the passage will be afterwards more fully quoted, we must here only say, that after enumerating Arthur, Lancelot, Godfrey, Roland, and other champions, he sums up his account of them as being the heroes

> "De quoi cils minestriers font les nobles romans."

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Maitre Wace, a canon of Caen, in Normandy, who, besides the metrical chronicle of *Le Brut*, containing the earliest history of England, and other historical legends, wrote, in 1155, the *Roman de Chevalier de Lyon*, probably the same translated under the title of *Ywain* and *Gawain*. Lambert li Cors, and Benoit de Saint-Maur, seem both to have been of the clerical order; and, perhaps, Chretien de Troyes, a most voluminous author of romance, was of the same profession. Indeed, the extreme length of many romances being much greater than any minstrel could undertake to sing at one or even many sittings, may induce us to refer them to men of a more sedentary occupation than those wandering poets. The religious romances were, in all probability, the works of such churchmen as might wish to reconcile an agreeable occupation with their religious profession. All which circumstances must be received as exceptions from the general proposition, that the romances in metre were the composition of the minstrels by whom they were recited or sung, though they must still leave Percy's proposition to a certain extent unimpeached.

Condition of the Minstrels.

To explain the history of Romance, it is necessary to digress a little further concerning the condition of the minstrels by whom these compositions were often made, and, generally speaking, preserved and recited. And here, it must be confessed, the venerable Prelate has, perhaps, suffered his love of antiquity, and his desire to ennoble the productions of the middle ages a little to overcolour the importance and respectability of the minstrel tribe; although his opponent Ritson has, on the other hand, seized on all circumstances and inferences which could be adduced to prove the degradation of the minstrel character, without attending to the particulars by which these depreciating circumstances were qualified. In fact, neither of these excellent antiquarians has cast a general or philosophical glance on the necessary condition of a set of men who were by profession the instruments of the pleasure of others during a period of society such as was presented in the middle ages.

In a very early period of society, ere the division of ranks had been generally adopted, and while each tribe may be yet considered as one great family, and the nation as an union of such independent tribes, the poetical art, so nearly allied to that of oratory or persuasion, is found to ascertain to its professors a very high rank. Poets are the historians and often the priests of the tribe. Their command of language, then in its infancy, excites not merely pleasure but enthusiasm and admiration. When separated into a distinct class, as was the case with the Celtic Bards, and, perhaps, with the Skalds of Scandinavia, they rank high in the scale of society, and we not only find Kings and Nobles listening to them with admiration, but emulous of their art, and desirous to be enrolled among their numbers. Several of the most renowned northern Kings and Champions valued themselves as much upon their powers of poetry as on their martial exploits; and of the Welsh Princes, the Irish Kings, and the Highland Chiefs of Scotland very many practised the arts of poetry and music. Llwarch Hen was a Prince of the Cymraig,—Brian, Boromhe, a harper and a musician,—and without resorting to the questionable authenticity of Ossian, several instances of the same kind might be produced in the Highlands.

But, in process of time, when the classes of society come to assume their usual gradation with respect to each other, the rank of professional poets is uniformly found to sink gradually in the scale, along with that of all others whose trade it is to contribute to the amusement of society. The mere professional poet, like the player or the musician, becomes the companion and soother only of idle and convivial hours; his presence would be unbecoming on occasions of gravity and importance; and his art is accounted at best an amusing but useless luxury. Although the intellectual pleasure derived from poetry or from the exhibition of the drama be of a different and much higher class than that derived from the accordance of sounds, or from the exhibition of feats of dexterity; still it will be found that the opinions and often the laws of society, while individuals of these classes are cherished and held in the highest estimation, has degraded the professions themselves among the idle, dissolute, and useless appendages of society. Although it may be accounted ungrateful in mankind thus to reward the instruments of their highest enjoyments, yet some justification is usually to be drawn from the manners of the classes who were thus lowered in public opinion. It must be remembered, that, as professors of this joyous science, as it was called, the minstrels stood in direct opposition to the more severe part of the Catholics, and to the monks in particular, whose vows bound them to practise virtues of the ascetic order, and to look upon every thing as profane which was connected with mere worldly pleasure. The manners of the minstrels themselves gave but too much room for clerical censure. They were the usual assistants at scenes, not merely of conviviality, but of licence; and as the companions and encouragers of revelling and excess, they became contemptible in the eyes, not only of the aged and the serious, but of the libertine himself, when his debauch palled on his recollection. The minstrels, no doubt, like their brethren of the stage, sought an apology in the corrupted taste and manners of their audience, with which they were obliged to comply, under the true but melancholy condition that

—they who live to please must please to live.

But this very necessity, rendered more degrading by their increasing numbers and decreasing reputation, only accelerated the total downfal of their order, and the general discredit and neglect into which they had fallen. The statute of the 39th Queen Elizabeth, passed at the close of the sixteenth century, ranks those dishonoured sons of song among rogues and vagabonds, and appoints them to be punished as such; and the occupation, though a vestige of it was long retained in the habits of travelling ballad-singers and musicians, sunk into total neglect and contempt. Of this we shall have to speak hereafter; our business being at present with those ro-

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mances, which, while still in the zenith of their reputation, were the means by which the minstrels, at least the better and higher class among them, recommended themselves to the favour of their noble patrons, and of the audiences whom they addressed.

It may be presumed, that, although the class of minstrels, like all who merely depend upon gratifying the public, carried in their very occupation the evils which first infected, and finally altogether depraved their reputation; yet, in the earlier ages, their duties were more honourably estimated, and some attempts were made to introduce into their motley body the character of a regular establishment, subjected to discipline and subordination. Several individuals, both of France and England, bore the title of King of Minstrels, and were invested probably with some authority over the others. The Serjeant of Minstrels is also mentioned; and Edward IV. seems to have attempted to form a Guild or exclusive Corporation of Minstrels. John of Gaunt, at an earlier period, established (between jest and earnest, perhaps) a Court Baron of Minstrels, to be held at Tilbury. There is no reason, however, to suppose that the influence of their establishments went far in restraining the licence of a body of artists so unruly as well as numerous.

It is not, indeed, surprising that individuals, whose talents in the arts of music or of the stage rise to the highest order, should, in a special degree, attain the regard and affection of the powerful, acquire wealth, and rise to consideration; for, in such professions, very high prizes are assigned to pre-eminent excellence; while ordinary or inferior practisers of the same art may be said to draw in the lottery something more than a mere blank. Garrick, in his chariot, and whose company was courted for his wit and talent, was, after all, by profession, the same with the unfortunate Stroller, whom the British laws condemn as a vagabond, and to whose dead body other countries refuse even the last rites of Christianity. In the same manner it is easy to suppose that, when in compliance with the taste of their age, monarchs entertained their domestic minstrels,* those persons might be admitted to the most flattering intimacy with their royal masters; sleep within the royal chamber, † amass considerable fortunes, found hospitals, ‡ and receive rewards singularly over-proportioned to the perquisites of the graver professions; § and even practise in company with their royal masters the pleasing arts of poetry and music, which all are so desirous of attaining; || whilst, at the same time, those who ranked lower in the same profession were struggling with difficulty to gain a precarious subsistence, and incurring all the disgrace usually attached to a vagabond life and a dubious character. In the fine arts, particularly, excellence is demanded, and mere mediocrity is held contemptible; and, while the favour with which the former is loaded, sometimes seems disproportioned to the utility of the art itself, nothing can exceed the scorn poured out on those who expose themselves by undertaking arts which they are unable to practise with success. Self-conceit, however, love of an idle life, and a variety of combined motives, never fail to recruit the lower orders of such idle professions with individuals by whose performances, and often by their private characters, the art which they have rashly adopted can only be discredited without any corresponding advantage to themselves. It is not, therefore, surprising that, while such distinguished examples of the contrary appeared amongst individuals, the whole body of minstrels, with the romances which they composed and sung, should be reprobated by graver historians in such severe terms as often occur in the monkish chronicles of the day.

Character and Style of the Romances of Chivalry.

Respecting the style of their composition, Du Cange inform us, that the minstrels sometimes devoted their strains to flatter the great, and sing the praises of those Princes by whom they were protected; while he owns, at the same time, that they often recommended to their hearers the path of virtue and nobleness, and pointed out the pursuits by which the heroes of romance had rendered themselves renowned in song. ¶ He quotes from the romance of *Bertrand Guesclin*, the injunction on those who would rise to fame in arms to copy the valiant acts of the Paladins of Charles, and the Knights of the Round Table, narrated in romances; and it cannot be denied, that those high tales, in which the vir-

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* Berdic (*Regis Joculator*), the jougleur or minstrel of William the Conqueror, had, as appears from the Domesday record, three vills and five caracates of land in Gloucestershire without rent. Henry I. had a minstrel called Galfrid who received an annuity from the abbey of Hide.

† A minstrel of Edward I., during that prince's expedition to the Holy Land, slept within his tent, and came to his assistance when an attempt was made to assassinate him.

‡ The Priory and Hospital of Saint Bartholomew, in London, was founded in the reign of Henry I. by Royer or Raher, a minstrel of that prince.

§ In 1441, the monks of Maxlock, near Coventry, paid a donation of four shillings to the minstrels of Lord Clinton for songs, harping, and other exhibitions, while, to a doctor who preached before the community in the same year, they assigned only sixpence.

|| The noted anecdote of Blondel and his royal master, Richard Cœur de Lion, will occur to every reader.

¶ Ministelli dicti præsertim Scurræ, mimi, joculatores, quos etiamnum vulgo *Menestreux* vel *Menestriers*, appellamus.——Porro ejusmodi scurrarum erat Principes non suis duntaxat ludicris oblectare, sed et eorum aures variis avorum, adeoque ipsorum Principum laudibus, non sine assentatione, cum cantilenis et musicis instrumentis, demulcere.——Interdum etiam virorum insignium et heroum gesta, aut explicata et jucunda narratione commemorabant, aut suavi vocis inflectione, fidibusque decantabant, quo sic dominorum, cæterorumque qui his intererant ludicris, nobilium animos ad virtutem capessendam et summorum virorum

tues of generosity, bravery, devotion to his mistress, and zeal for the Catholic religion, were carried to the greatest height of romantic perfection in the character of the hero, united with the scenes passing around them, were of the highest importance in affecting the character of the age. The fabulous knights of romance were so completely identified with those of real history, that graver historians quote the actions of the former in illustration of, and as a corollary to, the real events which they narrate. * The virtues recommended in romance were, however, only of that overstrained and extravagant cast which consisted with the spirit of chivalry. Great bodily strength, and perfection in all martial exercises, was the universal accomplishment inalienable from the character of the hero, and which each romancer had it in his power to confer. It was also easily in the composer's power to devise dangers, and to free his hero from them by the exertion of valour equally extravagant. But it was more difficult to frame a story which should illustrate the manners as well as the feats of chivalry; or to devise the means of evincing that devotion to duty, and that disinterested desire to sacrifice all to faith and honour;—that noble spirit of achievement which laboured for others more than itself—which form, perhaps, the fairest side of the system under which the noble youths of the middle ages were trained up. The sentiments of chivalry, as we have explained in our article on that subject, were founded on the most pure and honourable principles, but unfortunately carried into hyperbole and extravagance; until their religion approached to fanaticism, their valour to frenzy, their ideas of honour to absurdity, their spirit of enterprise to extravagance, and their respect for the female sex to a sort of idolatry. All those extravagant feelings, which really existed in the society of the middle ages, were magnified and exaggerated by the writers and reciters of romance; and these given as resemblances of actual manners became, in their turn, the glass by which the youth of the age dressed themselves; while the spirit of chivalry and of romance thus gradually threw light upon and enhanced each other.

The romances, therefore, exhibited the same system of manners which existed in the nobles of the age. The character of a true son of chivalry was raised to such a pitch of ideal and impossible perfection, that those who emulated such renown were usually contented to stop far short of the mark. The most adventurous and unshaken valour, a mind capable of the highest flights of romantic generosity, a heart which was devoted to the will of some fair idol, on whom his deeds were to reflect glory, and whose love was to reward all his toils,—these were attributes which all aspired to exhibit who sought to rank high in the annals of chivalry; and such were the virtues which the minstrels celebrated. But, like the temper of a tamed lion, the fierce and dissolute temper of the age often showed itself through the fair varnish of this artificial system of manners. The valour of the hero was often stained by acts of cruelty, or freaks of rash desperation; his courtesy and munificence became solemn foppery and wild profusion; his love to his lady often demanded and received a requital inconsistent with the honour of the object; and those who affected to found their attachment on the purest and most delicate metaphysical principles, carried on their actual intercourse with a licence altogether inconsistent with their sublime pretensions. Such were the real manners of the middle ages, and we find them so depicted in these ancient legends.

So high was the national excitation in consequence of the romantic atmosphere in which they seemed to breathe, that the knights and squires of the fourteenth and fifteenth centuries imitated the wildest and most extravagant emprises of the heroes of romance; and, like them, took on themselves the most extraordinary adventures to show their own gallantry, and do most honour to the ladies of their hearts. The females of rank, erected into a species of goddesses in public, and often degraded as much below their proper dignity in more private intercourse, equalled in their extravagances the youth of the other sex. A singular picture is given by Knyghton of the damsels errant who attended upon the solemn festivals of chivalry, in quest, it may reasonably be supposed, of such adventures as are very likely to be met with by such females as think proper to seek them. "These tournaments are attended by many ladies of the first rank and greatest beauty, but not always of the most untainted reputation. These ladies are dressed in party-coloured tunics,

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imitationem accenderent: quod fuit olim apud Gallos Bardorum ministerium, ut auctor est Tacitus. Neque enim alios à *Ministellis*, veterum Gallorum *Bardos* fuisse pluribus probat Henricus Valesius ad 15. Ammiani.—*Chronicon* Bertrandi Guesclini:

Qui veut avoir renom des bons et des vaillans,
Ill doit aler souvent à la pluie et au champ,
Et estre en la bataille, ainsy que fu Rollans,
Les quatre fils Haimon et Charlon li plus grans,
Li Dus Lions de Bourges, et Guion de Connans,
Perceval li Galois, Lancelot et Tristans,
Alexandres, Artus, Godefroy li sachans,
De quoy cils Menestriers font les nobles Romans.

* Barbour, the Scottish historian, censures a Highland chief, when, in commending the prowess of Bruce in battle, he likened him to the Celtic hero, Fin Mac Coul, and says, he might in more mannerly fashion have compared him to Gaudifer, a champion celebrated in the romance of Alexander.

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one-half of one colour, and the other half of another; their lirripipes, or tippets, are very short; their caps remarkably little, and wrapt about their heads with cords; their girdles and pouches are ornamented with gold and silver; and they wear short swords, called *daggers*, before them, a little below their navels; they are mounted on the finest horses, with the richest furniture. Thus equipped, they ride from place to place in quest of tournaments, by which they dissipate their fortunes, and sometimes ruin their reputation."—(Knyghton, quoted in Henry's *History*, Vol. VIII. p. 402.)

The minstrels, or those who aided them in the composition of the romances, which it was their profession to recite, roused to rivalry by the unceasing demand for their compositions, endeavoured emulously to render them more attractive by subjects of new and varied interest, or by marvellous incidents which their predecessors were strangers to. Much labour has been bestowed, somewhat unprofitably, in endeavouring to ascertain the sources from which they drew the embellishments of their tales, when the hearers began to be tired of the unvaried recital of battle and tournament which had satisfied the simplicity of a former age. Percy has contended for the Northern *Sagas* as the unquestionable origin of the romance of the middle ages; Warton conceived that the *Oriental fables*, borrowed by those minstrels who visited Spain, or who in great numbers attended the crusades, gave the principal distinctive colouring to those remarkable compositions; and a later system, patronised by later authors, has derived them, in a great measure, from the fragments of classical superstition, which continued to be preserved after the fall of the Roman Empire. All those systems seem to be inaccurate, in so far as they have been adopted, exclusively of each other, and of the general proposition, That fables of a nature similar to the romances of chivalry, modified according to manners and state of society, must necessarily be invented in every part of the world, for the same reason that grass grows upon the surface of the soil in every climate and in every country. "In reality," says Mr Southey, who has treated this subject with his usual ability, "mythological and romantic tales are current among all savages of whom we have any full account; for man has his intellectual as well as his bodily appetites, and these things are the food of his imagination and faith. They are found wherever there is language and discourse of reason, in other words, wherever there is man. And in similar stages of civilization, or states of society, the fictions of different people will bear a corresponding resemblance, notwithstanding the difference of time and scene." *

To this it may be added, that the usual appearances and productions of nature offer to the fancy, in every part of the world, the same means of diversifying fictitious narrative by the introduction of prodigies. If in any romance we encounter the description of an elephant, we may reasonably conclude that a phenomenon, unknown in Europe, must have been borrowed from the east; but whosoever has seen a serpent and a bird, may easily aggravate the terrors of the former by conferring on a fictitious monster the wings of the latter; and whoever has seen or heard of a wolf, or lion, and an eagle, may, by a similar exertion of invention, imagine a griffin or hippogriff. It is imputing great poverty to the human imagination, to suppose that the *speciosa miracula*, which are found to exist in different parts of the world, must necessarily be derived from some common source; and perhaps we should not err more grossly in supposing that the various kinds of boats, skiffs, and rafts, upon which men have dared the ocean on so many various shores, have been all originally derived from the vessel of the Argonauts.

On the other hand, there are various romantic incidents and inventions of a nature so peculiar, that we may boldly, and at once, refer them to some particular and special origin. The tale of *Flora and Blanchefleur*, for example, could only be invented in the east, where the scene is laid, and the manners of which are observed with some accuracy. That of *Orfeo and Herodiis*, on the contrary, is the classical history of Orpheus and Euridice, with the Gothic machinery of the Elves or Fairies, substituted for the infernal regions. But notwithstanding these and many other instances in which the subjects or leading incidents of romance can be distinctly traced to British or Armorican traditions, to the tales and history of Classic Antiquity, to the wild fables and rich imagery of Arabia, or to those darker and sterner themes which were first treated of by the Skalds of the north, it would be assuming greatly too much upon such grounds, to ascribe the derivation of romantic fiction, exclusively to any one of these sources. In fact, the foundation of these fables lies deep in human nature, and the superstructures have been imitated from various authorities by those who, living by the pleasure which their lays of chivalry afforded to their audience, were especially anxious to recommend them by novelty of every kind; and were undoubtedly highly gratified when the report of travellers, or pilgrims, or perhaps their own intercourse with minstrels of other nations, enabled them to vary their usual narrations with circumstances yet unheard in Bower and Hall. Romance, therefore, was like a compound metal, derived from various mines, in which one metal or other was alternately predominant; and viewed in this light, the ingenious labours of those learned antiquaries, who have endeavoured to seek the origin of this style of fiction in one of these sources alone, to the exclusion of all others, seem as vain as that of travellers affecting to trace the proper head of the Nile to various different springs, all of which are allowed to be accessary to form the full majesty of his current.

Prose Romance.

As the fashion of all things pass away, the metrical romances began gradually to decline in public estimation, probably on account of the depreciated charac-

* Preface to Southey's edition of the *Morte D'Arthur*, Vol. II. Lond. 1817.

ter of the minstrels by whom they were recited. Tradition, says Ritson, is an alchemy, which converts gold into lead; and there is little doubt, that, in passing from mouth to mouth, and from age to age, the most approved metrical romances became gradually corrupted by the defect of memory of some reciters and the interpolations of others; since few comparatively can be supposed to have had recourse to the manuscripts in which some have been preserved. Neither were the reciters in the latter, as in the former times, supplied with new compositions of interest and merit. The composition of the metrical romance was gradually abandoned to persons of an inferior class. The art of stringing together in loose verse a number of unconnected adventures, was too easy not to be practised by many who only succeeded to such a degree as was discreditable to the art, by showing that mere mediocrity was sufficient to practise it. And the licentious character, as well as the great number of those who, under the various names of glee-men, minstrels, and the like, traversed the country, and subsisted by this idle trade, brought themselves and their occupation into still greater contempt and disregard. With them, the long recitations formerly made at the tables of the great, were gradually banished into more vulgar society.

But though the form of those narratives underwent a change of fashion, the appetite for the fictions themselves continued as ardent as ever; and the Prose Romances which succeeded, and finally superseded those composed in verse, had a large and permanent share of popularity. This was, no doubt, in a great degree owing to the important invention of printing, which has so much contributed to alter the destinies of the world. The metrical romances, though in some instances sent to the press, were not very fit to be published in this form. The dull amplifications which passed well enough in the course of a half-heard recitation, became intolerable when subjected to the eye; and the public taste gradually growing more fastidious as the language became more copious, and the system of manners more complicated, graces of style and variety of sentiment were demanded instead of a naked and unadorned tale of wonders. The authors of the prose romance endeavoured, to the best of their skill, to satisfy this newly awakened and more refined taste. They used, indeed, the same sources of romantic history which had been resorted to by their metrical predecessors; and Arthur, Charlemagne, and all their chivalry, were as much celebrated in prose as ever they had been in poetic narrative. But the new candidates for public favour pretended to have recourse to sources of authentic information, to which their metrical predecessors had no access. They refer almost always to Latin and sometimes to Greek originals, which certainly had no existence; and there is little doubt that the venerable names of the alleged authors are invented, as well as the supposed originals from which they are said to have translated their narratives. The following account of the discovery of *La tres elegante delicieux melliflue et tres plaisante hystoire du tres Noble Roy Perceforest* (printed at Paris in 1528 by Galliot du Pré), may serve to show that modern authors were not the first who invented the popular mode of introducing their works to the world as the contents of a newly discovered manuscript. In the abridgment to which we are limited, we can give but a faint picture of the minuteness with which the author announces his pretended discovery, and which forms an admirable example of the lie with a circumstance. In the year 1286, Count William of Hainault had, it is averred, crossed the seas in order to be present at the nuptials of Edward, and in the course of a tour through Britain, was hospitably entertained at an abbey situated on the banks of the Humber, and termed, it seems, Burtimer, because founded by a certain Burtimericus, a monarch of whom our annals are silent, but who had gained, in that place, a victory over the heathens of Germany. Here a cabinet, which was inclosed in a private recess, had been lately discovered within the massive walls of an ancient tower, and was found to contain a Grecian manuscript, along with a royal crown. The abbot had sent the latter to King Edward, and the Count of Hainault with difficulty obtained possession of the manuscript. He had it rendered from Greek into Latin by a monk of the abbey of Saint Landelain, and from that language it is said to have been translated into French by the author, who gives it to the world in honour of the Blessed Virgin, and for the edification of nobleness and chivalry.

By such details, the authors of the prose romances endeavoured to obtain for their works a credit for authenticity which had been denied to the rythmical legends. But in this particular they did great injustice to their contemned predecessors, whose reputations they murdered in order to rob them with impunity. Whatever fragments or shadowings of true history may yet remain hidden under the mass of accumulated fable, which had been heaped on them during successive ages, must undoubtedly be sought in the metrical romances; and according to the view of the subject which we have already given, the more the works approach in point of antiquity to the period where the story is laid, the more are we likely to find those historical traditions in something approaching to an authentic state. But those who wrote under the imaginary names of Rusticien de Puise, Robert de Borron, and the like, usually seized upon the subject of some old minstrel; and, recomposing the whole narrative after their own fashion, with additional characters and adventures, totally obliterated in that operation any shades which remained of the original, and probably authentic tradition, which was the original source of the elaborate fiction. Amplification was especially employed by the prose romancers, who, having once got hold of a subject, seem never to have parted with it until their power of invention was completely exhausted. The metrical romances, in some instances, indeed, ran to great length, but were much exceeded in that particular by the folios which were written on the same or similar topics by their prose successors. Probably the latter judiciously reflected that a book which addresses itself only to the eyes, may be laid aside when it becomes tiresome to the reader; whereas it may not always have been so easy to stop the minstrel in the full career of his metrical declamation.

Who, then, the reader may be disposed to inquire,

can have been the real authors of those prolix works, who, shrouding themselves under borrowed names, derived no renown from their labours, if successful, and who, certainly, in the infant state of the press, were not rewarded with any emolument? This question cannot, perhaps, be very satisfactorily answered; but we may reasonably suspect that the long hours of leisure which the cloister permitted to its votaries, were often passed away in this manner; and the conjecture is rendered more probable, when it is observed that matters are introduced into those works which have an especial connection with sacred history, and with the traditions of the church. Thus, in the curious romance of *Huon de Bourdeaux*, a sort of second part is added to that delightful history, in which the hero visits the terrestrial paradise, encounters the first murderer Cain, in the performance of his penance, with more matter to the same purpose, not likely to occur to the imagination of a layman; besides, that the laity of the period were, in general, too busy and too ignorant to engage in literary tasks of any kind. The mystical portion of the romance of the *Round Table* seems derived from the same source. It may also be mentioned, that the audacious and sometimes blasphemous assertions, which claimed for these fictions the credit due even to the inspired writings themselves, were likely to originate amongst Roman Catholic churchmen, who were but too familiar with such forgeries for the purpose of authenticating the legends of their superstition. One almost incredible instance of this impious species of imposture occurs in the history of the *Saint Graal*, which curious mixture of mysticism and chivalry is ascribed by the unfearing and unblushing writer to the Second Person of the Trinity.

Churchmen, however, were by no means the only authors of these legends, although the *Sires Clercs*, as they were sometimes termed, who were accounted the chronicles of the times in which they lived, were usually in orders; and although it appears that it was upon them that the commands of the sovereigns whom they served often imposed the task of producing new romances under the usual disguise of ancient chronicles translated from the learned languages, or otherwise collected from the ruins of antiquity. As education became improved, and knowledge began to be more generally diffused, individuals among the laity, and those of no mean rank, began to feel the necessity, as it may be called, of putting into a permanent form the "thick-coming fancies" which gleam alongst the imagination of men of genius. Sir Thomas Malony, who compiled the *Morte D'Arthur* from French originals, was a person of honour and worship; and Lord Berners, the excellent translator of Froissart, and author of a romance called *The Chevalier de la Cygne*, is an illustrious example that a nobleman of high estimation did not think his time misemployed on this species of composition. Some literary fame must therefore have attended these efforts; and perhaps less eminent authors might, in the later ages, receive some pecuniary advantages. The translator of *Perceforest*, formerly mentioned, who appears to have been an Englishman or Fleming, in his address to the warlike and invincible nobility of France, holds the language of a professional author, who expected some advantage besides that of pleasing those whom he addressed; and who expresses proportional gratitude for the favourable reception of his former feeble attempts to please them. It is possible, therefore, that the publishers, these lions of literature, had begun already to admit the authors into some share of their earnings. Other printers, like the venerable Caxton, compiled themselves, or translated from other languages, the romances which they sent to the press; thus uniting in their own persons the three separate departments of author, printer, and publisher.

The prose romance did not, in the general conduct of the story, where digressions are heaped on digressions, without the least respect to the principal narrative, greatly differ from that of their metrical predecessors, being, to the full, as tedious and unartificial; nay, more so in proportion as the new romances were longer than the old. In the transference from verse to prose, and the amplification which the scenes underwent in the process, many strong, forcible, and energetic touches of the original author have been weakened, or altogether lost; and the reader misses with regret some of the redeeming bursts of rude poetry which, in the metrical romance, makes amends for many hundred lines of bald and rude versification. But, on the other hand, the prose romances were written for a more advanced stage of society, and by authors whose language was much more copious, and who certainly belonged to a more educated class than the ancient minstrels. Men were no longer satisfied with hearing of hard battles and direful wounds; they demanded, at the hand of those who professed to entertain them, some insight into nature, or at least into manners; some description of external scenery, and a greater regard to probability both in respect of the characters which are introduced, and the events which are narrated. These new demands the prose romances endeavoured to supply to the best of their power. There was some attention shown to relieve their story, by the introduction of new characters, and to illustrate these personages by characteristic dialogue. The lovers conversed with each other in the terms of metaphysical gallantry, which were used in real life; and from being a mere rhapsody of warlike feats, the romance began to assume the nobler and more artificial form of a picture of manners. It is in the prose folios of *Lancelot du Lac*, *Perceforest*, and others, that antiquarians find recorded the most exact accounts of fights, tournaments, feasts, and other magnificent displays of chivalric splendour; and as they descend into more minute description than the historians of the time thought worthy of their pains, they are a mine from which the painful student may extract much valuable information. This, however, is not the full extent of their merit. These ancient books, amid many pages of dull repetition and uninteresting dialect, and notwithstanding the languor of an inartificial, protracted, and confused story, exhibit from time to time passages of deep interest, and situations of much novelty, as well as specimens of spirited and masculine writing. The general reader, who dreads the labour of winnowing out these

valuable passages from the sterile chaff through which they are scattered, will receive an excellent idea of the beauties and defects of the romance from Tressan's *Corps d'Extraits de Romans de Chevalrie*, from Mr Ellis's *Specimens of Early English Romances*, and Mr Dunlop's *History of Fiction*.

These works continued to furnish the amusement of the most polished courts in Europe so long as the manners and habits of chivalry continued to animate them. Even the sagacious Catherine of Medicis considered the romance of *Perceforest* as the work best qualified to form the manners and amuse the leisure of a young prince; since she impressed on Charles IX. the necessity of studying it with attention. But by degrees the progress of new opinions in religion, the promulgation of a stricter code of morality, together with the important and animating discussions which began to be carried on by means of the press, diverted the public attention from these antiquated legends. The Protestants of England, and the Huguenots of France, were rigorous in their censure of books of chivalry, in proportion as they had been patronized formerly under the Catholic system; perhaps because they helped to arrest men's thoughts from more serious subjects of occupation. The learned Ascham thus inveighs against the romance of *Morte D'Arthur*, and at the same time acquaints us with its having passed out of fashion: "In our forefathers' tyme, when papistrie, as a standyng poole, covered and overflowed all *Englande*, fewe bookes were read in our tongue, savyng certaine bookes of chevalrie, as they said for pastime and pleasure; which, as some say, were made in monasteries by idle monks, or wanton chanons. As for example, *La Morte D'Arthur*, the whole pleasure of which booke standeth in two speciall poyntes, in open manslaughter, and bold bawdrye: in which booke they counted the noblest knightes that do kill most men without any quarrell, and commit fowlest adulteries by sutlest shiftes; as Sir *Launcelote*, with the wife of King *Arthur* his master; Sir *Tristram*, with the wife of King *Marke* his uncle; Sir *Lamerocke*, with the wife of King *Lote*, that was his own aunt. This is good stuffe for wise men to laughe at, or honest men to take pleasure at: yet I know, when God's Bible was banished the court, and *La Morte D'Arthur* received into the prince's chamber."*

The brave and religious La Noue is not more favourable to the perusal of romances than the learned Ascham; attributing to the public taste for these compositions the decay of morality among the French nobility. "The ancient fables whose relikes doe yet remaine, namely, *Lancelot of the Lake*, *Pierceforest*, *Tristran*, *Giron the Courteous*, and such others, doe beare witnesse of this olde vanitie; herewith were men fed for the space of 500 yeeres, untill our language growing more polished, and our mindes more ticklish, they were driven to invent some nouelties wherewith to delight us. Thus came y^e^ bookes of *Amadis* into light among us in this last age. But to say y^e^ truth, *Spaine* bred thē, and *France* new clothed thē in gay garments. In y^e^ daies of *Henrie the Second* did they beare chiefest sway, and I think if any man would then have reproved thē, he should have bene spit at, because they were of themselves playfellowes and maintainers to a great sort of persons; whereof some, after they had learned to amize in speech, their teeth watered, so desirous were they even to taste of some small morsels of the delicaces therein most livelie and naturally represented."† The gallant Marechal proceeds at considerable length to refute the arguments of those who contended that these books were intended as a spur to the practice of arms and honourable exercises amongst youth, and labours hard to show that they teach dishonest practices both in love and in arms. It is impossible to suppress a smile when we find such an author as La Noue denouncing the introduction of spells, witchcrafts, and enchantments into these volumes, not because such themes are absurd and nonsensical, but because the representing such beneficent enchanters as Alquife and Urganda is, in fact, a vindication of those who traffic with the powers of darkness; and that those who love to read about sorceries and enchantments become, by degrees, familiarized with those devilish mysteries, and may at length be induced to have recourse to them in good earnest.

The romances of chivalry did not, however, sink into disrepute under the stern rebuke of religious puritans or severe moralists, but became gradually neglected as the customs of chivalry itself fell into disregard; when, of course, the books which breathed its spirit, and were written under its influence, ceased to produce any impression on the public mind, and, superseded by better models of composition, and overwhelmed with the ridicule of Cervantes, sunk by degrees into utter contempt and oblivion.

Other works of amusement, of the same general class, succeeded the proper romance of chivalry. Of these we shall take some notice hereafter; since we must here close our general view of the history of romance, and proceed briefly to give some account of those peculiar to the various European nations.

Romances of the different Countries of Europe.

II. We can here but briefly touch upon a subject of great interest and curiosity, the peculiar character and tone, namely, which the romance of chivalry received from the manners and early history of the nations among whom it is found to exist; and the corresponding question, in what degree each appears to have borrowed from other countries the themes of their own minstrels, or to have made use of materials common to the whole.

Northern Romances.

Scandinavia, as was to be expected, may be safely considered as the richest country in Europe in ancient tales corresponding with the character of romance; sometimes composed entirely in poetry or rythm, sometimes in prose, and much more frequent-

* *Works* of Roger Ascham, p. 254. 4to edition.

† *The Politicke and Militarie Discourses* of the Lord De La Nowe, pp. 87, 88. Quarto, Lond. 1587.

ly in a mixture of prose, narrative, and lyrical effusions. Their well-known Skalds or bards held a high rank in their courts and councils. The character of a good poet was scarce second to that of a gallant leader, and many of the most celebrated champions ambitiously endeavoured to unite both in their own persons. Their earlier Sagas or tales approach to the credit of real history, and were unquestionably meant as such, though, as usual at an early period, debased by the intermixture of those *speciosa miracula* which the love of the wonderful early introduces into the annals of an infant country. There are, however, very many of the sagas, indeed by far the greater number of those now known to exist, which must be considered as falling rather under the class of fictitious than of real narratives; and which, therefore, belong to our present subject of inquiry. The *Omeyinger Saga*, the *Heimskringla*, the *Saga* of Olaf Triggwason, the *Eirbyggia Saga*, and several others, may be considered as historical; whilst the numerous narratives referring to the history of the Nibilungen and Volsungen are as imaginary as the romances which treat of King Arthur and of Charlemagne. These singular compositions, short, abrupt, and concise in expression, full of bold and even extravagant metaphor, exhibiting many passages of forceful and rapid description, hold a character of their own; and while they remind us of the indomitable courage and patient endurance of the hardy Scandinavians, at once the honour and the terror of Europe, rise far above the tedious and creeping style which characterised the minstrel efforts of their successors, whether in France or England. In the pine forests also, and the frozen mountains of the north, there were nursed, amid the reliques of expiring paganism, many traditions of a character more wild and terrible than the fables of classical superstition; and these the gloomy imagination of the skalds failed not to transfer to their romantic tales. The late spirit of inquiry which has been so widely spread through Germany, has already begun to throw much light on this neglected storehouse of romantic lore, which is worthy of much more attention than has yet been bestowed upon it in Britain. It must, however, be remarked, that although the north possesses champions and romances of its own, unknown to southern song, yet, in a later age, the inhabitants of these countries borrowed from the French minstrels some of their most popular subjects; and hence we find sagas on the subject of Sir Tristrem, Sir Percival, Sir Ywain, and others, the well-known themes of French and English romance. These, however, must necessarily be considered later in date, as well as far inferior in interest, to the sagas of genuine northern birth. Mr Ritson has indeed quoted their existence as depreciating the pretensions of the northern nations to the possession of poems of high antiquity of their own native growth. Had he been acquainted with the *Norman-Kiempe-Datur*, a large folio, printed at Stockholm in 1737, he would have been satisfied, that out of the numerous collection of legends respecting the achievements of Gothic champions, far the greater part are of genuine Norse origin; and although having many features in common with the romances of southern chivalry, are, in other marked particulars, distinctly divided from that class of fictitious composition.

German Romance.

The country of Germany, lying contiguous to France, and constantly engaged in friendly and hostile intercourse with that great seat of romantic fiction, became, of course, an early partaker in the stores which it afforded. The Minnesingers of the Holy Empire were a race no less cherished than the Troubadours of Provence, or the Minstrels of Normandy; and no less active in availing themselves of their indigenous traditions, or importing those of other countries, in order to add to their stock of romantic fiction. Godfred of Strasburgh composed many thousand lines upon the popular subject of Sir Tristram; and others have been equally copious, both as translators and as original authors, upon various subjects connected with French romance; but Germany possessed materials, partly borrowed from Scandinavia, partly peculiar to her own traditional history, as well as to that of the Roman empire, which they applied to the construction of a cycle of heroes as famous in Teutonic song as those of Arthur and of Charlemagne in France and Britain.

As in all other cases of the kind, a real conqueror, the fame of whose exploits survived in tradition, was adopted as the central object, around whom were to be assembled a set of champions, and with whose history was to be interwoven the various feats of courage which they performed, and the adventures which they underwent. Theodorick King of the Goths, called in these romantic legends Diderick of Bern (*i. e.* Verona), was selected for this purpose by the German Minnesingers. Amongst the principal personages introduced are Ezzel, King of the Huns, who is no other than the celebrated Attila; and Gunter, King of Burgundy, who is identified with a Guntachar of history who really held that kingdom. The good knight Wolfram de Eschenbach seems to have been the first who assembled the scattered traditions and minstrel tales concerning these sovereigns into one large volume of German verse, entitled *Helden-Buch*, or the Book of Heroes. In this the author has availed himself of the unlimited licence of a romancer; and has connected with the history of Diderick and his chivalry a number of detached legends which had certainly a separate and independent existence. Such is the tale of *Sigurd the Horny*, which has the appearance of having originally been a Norse Saga. An analysis of this singular piece was published by Mr Weber, in a work entitled *Illustrations of Northern Antiquities, from the earlier Teutonic and Scandinavian Romances*; and the subject has been fully illustrated by the publications of the learned Von der Hagen in Germany, and those of the Honourable William Herbert.

It is here only necessary to say, that Theodorick, like Charlemagne and Arthur, is considered in the romance as a monarch more celebrated for the valorous achievements of the brotherhood of chivalry whom he has drawn around him than for his own, though neither deficient in strength or courage. His principal followers have each their discriminatory and peculiar attributes. Meister Hildebrand, the Nestor of the band, is, like the Maugis of Charle-

magne's heroes, a magician as well as a champion. Hogan, or Hagan, begot betwixt a mortal and a sea-goblin, is the fierce Achilles of the confederation. It is the uniform custom of the romancers to conclude by a general and overwhelming catastrophe, which destroys the whole ring of chivalry whose feats they had commemorated. The ruin which Roncesvalles brought to the Paladins of Charlemagne, and the fatal battle of Camlan to the Knights of the Round Table, fell upon the warriors of Diderick through the revengeful treachery of Crimhilda, the wife of Ezzel; who, in revenge for the death of her first husband, and in her inordinate desire to possess the treasures of the Niflunga or Burgundians, brought destruction on all these celebrated champions. Mr Weber observes that these German fictions differ from the romances of French chivalry, in the greater ferocity and less refinement of sentiment ascribed to the heroes; and also in their employing to a great extent the machinery of the Duergar, or Dwarfs, a subterranean people to whom the *Helden-Buch* ascribes much strength and subtilty, as well as profound skill in the magic art; and who seem, to a certain extent, the predecessors of the European fairy.

Italian Romance.

Italy, so long the seat of classical learning, and where that learning was first revived, seems never to have strongly embraced the taste for the Gothic romance. They received, indeed, the forms and institutions of chivalry, but the Italians seem to have been in a considerable degree strangers to its spirit, nor to have become deeply enamoured of its literature. There is an old romance of chivalry proper to Italy, called *Guerino the Wretched*, but we doubt if even this be of indigenous growth. Indeed, when they did adopt from the French the fashionable tales of Charlemagne and his Paladins, they did not attract the attention of the classical Italians, until Boiardo, Berni, Pulci, and, above all, the divine Ariosto, condescended to use them as the basis of their well-known romantic poems; and thus the fictitious narratives originally composed in metre, and after rewritten in prose, were anew decorated with the honours of verse. The romantic poets of Italy did not even disdain to imitate the rambling, diffuse, and episodical style proper to the old romance; and Ariosto, in particular, although he torments the reader's attention by digressing from one adventure to another, delights us, upon frequent perusals, by the extreme ingenuity with which he gathers up the broken ends of his narrative, and finally weaves them all handsomely together in the same piece. But the merits and faults of romantic poetry form themselves the fruitful subject of a long essay. We here only notice the origin of those celebrated works, as a species of composition arising out of the old romance, though surpassing it in regularity, as well as in all the beauties of style and diction.

Spanish and Portuguese Romance.

With Spain the idea of romance was particularly connected; and the associations which are formed upon perusing the immortal work of Cervantes, induce us for a long time to believe that the country of Don Quixote must be the very cradle of romantic fiction. Yet, if we speak of priority of date, Spain was among the last nations in Europe with whom romance became popular. It was not indeed possible that, among a people speaking so noble and poetical a language, engaged in constant wars, which called forth at once their courage and their genius, there should not exist many historical and romantic ballads descriptive of their rencounters with the Moors. But their native poets seem to have been too much engaged with the events of their own age, or of that which had just preceded them, to permit of their seeking subjects in the regions of pure fiction; and we have not heard of a Spanish metrical romance, unless the poems describing the adventures of the Cid, should be supposed to have any affinity to that class of composition. The Peninsula, however, though late in adopting the prevailing taste for romantic fiction, gave origin to one particular class, which was at least as popular as any which had preceded it. *Amadis de Gaul*, the production, it would seem, of Vasco de Lobeira, a Portuguese knight, who lived in the fourteenth century, gave a new turn to the tales of chivalry; and threw into the shade the French prose romances, which, until the appearance of this distinguished work, had been the most popular in Europe.

The author of *Amadis*, in order, perhaps, to facilitate the other changes which he introduced, and to avoid rushing against preconceived ideas of events or character, laid aside the worn-out features of Arthur and Charlemagne, and imagined to himself a new dynasty both of sovereigns and of heroes, to whom he ascribed a style of manners much more refined, and sentiments much more artificial, than had occurred to the authors of *Perceval* or *Perceforest*. Lobeira had also taste enough to perceive, that some unity of design would be a great improvement on the old romance, where one adventure is strung to another with little connection from the beginning to the end of the volume; which thus concludes, not because the plot was winded up, but because the author's invention, or the printer's patience, was exhausted. In the work of the Portuguese author, on the contrary, he proposes a certain end, to advance or retard which all the incidents of the work have direct reference. This is the marriage of Amadis with Oriana, against which a thousand difficulties are raised by rivals, giants, sorcerers, and all the race of evil powers unfavourable to chivalry; whilst these obstacles are removed by the valour of the hero, and constancy of the heroine, succoured on their part by those friendly sages, and blameless sorceresses, whose intervention gave so much alarm to the tender-conscienced De la Noue. Lobeira also displayed considerable attention to the pleasure which arises from the contrast of character; and to relieve that of Amadis, who is the very essence of chivalrous constancy, he has introduced Don Galaor, his brother, a gay libertine in love, whose adventures form a contrast with those of his more serious brother. Above all, the *Amadis* displays an attention to the style and conversation of the piece, which, although its effects are now exaggerated and ridiculous, was doubtless at the time considered as the pitch of elegance; and here were, for the first time, introduced those hyper-

bolical compliments, and that inflated and complicated structure of language, the sense of which walks as in a masquerade.

The *Amadis* at first consisted only of four books, and in that limited shape may be considered as a very well conducted story; but additions were speedily made which extended the number to twenty-four; containing the history of Amadis subsequent to his obtaining possession of Oriana, and down to his death, as also of his numerous descendants. The theme was not yet exhausted; for, as the ancient romancers, when they commenced a new work, chose for their hero some newly invented Paladin of Charlemagne, or knight of King Arthur, so did their successors adopt a new descendant of the family of Amadis, whose genealogy was thus multiplied to a prodigious degree. For an account of *Esplandian, Florimond* of *Greece*, *Palmerin of England*, and the other romances of this class, the reader must be referred to the valuable labours of Mr Southey, who has abridged both *Amadis* and *Palmerin* with the most accurate attention to the style and manners of the original. The books of *Amadis* became so very popular, as to supersede the elder romances almost entirely, even at the court of France, where, according to La Noue, already quoted, they were introduced about the reign of Henry II. It was against the extravagance of these fictions in character, and in style, that the satire of Cervantes was chiefly directed; and almost all the library of Don Quixote belongs to this class of romances, which, no doubt, his adventures contributed much to put out of fashion.

French Romance.

In every point of view, France must be considered as the country in which chivalry and romance flourished in the highest perfection; and the originals of almost all the early romances, whether in prose or verse, whether relating to the history of Arthur or of Charlemagne, are to be found in the French language; and other countries possess only translations from thence. This will not be so surprising when it is recollected, that these earlier romances were written, not only for the use of the French, but of the English themselves, amongst whom French was the prevailing language during the reigns of the Anglo-Norman monarchs. Indeed, it has been ingeniously supposed, and not without much apparent probability, that the fame of Arthur was taken by the French minstrels for the foundation of their stories in honour of the English kings, who reigned over the supposed dominions of that British hero; while, on the other hand, the minstrels who repaired to the coast of France, celebrated the prowesses of Charlemagne and his twelve peers as a subject more gratifying to those who sat upon his throne. It is, perhaps, some objection to this ingenious history, that, as we have already seen, the battle of Hastings was opened by a minstrel, who sung the war-song of Roland, the nephew of Charlemagne; so that the Norman duke brought with him to England the tales that are supposed, at a much later date, to have been revived to soothe the national pride of the French minstrels.

How the French minstrels came by the traditional reliques concerning Arthur and Merlin, on which they wrought so long and so largely, must, we fear, always remain uncertain. From the Saxons we may conclude they had them not; for the Saxons were the very enemies against whom Arthur employed his good sword excalibar, that is to say, if there was such a man, or such a weapon. We know, indeed, that the British, like all the branches of the Celtic race, were much attached to poetry and music, which the numerous reliques of ancient poetry in Wales, Ireland, and the Highlands of Scotland, sufficiently evince. Arthur, a name famous among them, with some traditions concerning the sage Merlin, may have floated either in Armorica, or among the half-British of the borders of Scotland, and of Cumberland; and thus preserved, may have reached the ear of the Norman minstrels, either in their newly conquered dominions, or through their neighbours of Britanny. A theme of this sort once discovered, and found acceptable to the popular ear, gave rise, of course, to a thousand imitations; and gradually drew around it a cloud of fiction which, embellished by such poetry as the minstrels could produce, arranged itself by degrees into a system of fabulous history, as the congregated vapours touched by the setting sun, assume the form of battlements and towers. We know that the history of Sir Tristram, first versified by Thomas the Rymer of Ercildoune, was derived from Welsh traditions, though told by a Saxon poet. In fact, it may be easily supposed, that the romancers of that early period were more eager to acquire popular subjects than delicately scrupulous of borrowing from their neighbours; and when the foundation-stone was once laid, each subsequent minstrel brought his contribution to the building. The idea of an association of knights assembled around one mighty sovereign, was so flattering to all the ruling princes of Europe, that almost all of them endeavoured to put themselves at the head of some similar institution. The historical foundation of this huge superstructure is almost imperceptible. Mr Turner has shown that the evidence rather inclines to prove the actual existence of King Arthur; and the names of Gawain, his nephew, and of Genuera, his faithful spouse, of Mordred, and Merlin, was preserved by Welsh tradition. To the same source may be referred the loves of Tristrem and Ysolde, which, although a separate story, has become, in the later romances, amalgamated with that of Arthur. But there can be little doubt that all beyond the bare names of the heroes owes its existence to the imagination of the romancers.

It might be thought that the romances referring to the feats of Charlemagne ought to contain more historical truth than those concerning Arthur; since the former relate to a well-known monarch and conqueror, the latter to a personage of a very doubtful and shadowy existence. But the romances concerning both are equally fabulous. Charles had, indeed, an officer named Roland, who was slain with other nobles in the field of Roncesvalles, fighting, not against the Saracens or Spaniards, but against the Gascons. This is the only point upon which the real history of Charlemagne coincides with that invented for him by romancers. Roland was Prefect of Bretagne, and his memory was long preserved in the war-song which bore his name. A fabulous chronicler, calling himself

Romance. Turpin, compiled, in or about the eleventh century, a romantic history of Charlemagne; but it may be doubted whether, in some instances, he has not availed himself of the fictions already devised by the early romancers, while to those who succeeded them his annals afforded matter for new figments. The personal character of Charlemagne has suffered considerably in the hands of the romantic authors, although they exaggerated his power and his victories. He is represented as fond of flattery, irritable in his temper, ungrateful for the services rendered him by his most worthy Paladins, and a perpetual dupe to the treacherous artifices of Count Gan, or Ganelon, of Mayence; a renegade to whom the romancers impute the defeat at Roncesvalles, and all the other misfortunes of the reign of Charles. This unfavourable view of the Prince, although it may bear some features of royalty, neither resembles the real character of the conqueror of the Saxons and Lombards, nor can be easily reconciled with the idea, that he was introduced to flatter the personal vanity of the princes of the Valois race, by a portrait of their great predecessor.

The circumstance, that Roland was a lieutenant of Britanny, and the certainty that Marie borrowed from that country the incidents out of which she composed her lays, seems to fortify the theory, that the French minstrels obtained from that country much of their most valuable materials; and that, after all that has been said and supposed, the history of Arthur probably reached them through the same channel.

The Latin writers of the middle ages afforded the French romancers the themes of these metrical legends which they have composed on subjects of classical fame.

The honour of the prose romances of chivalry, exclusive always of the books of Amadis, belongs entirely to the French, and the curious volumes which are now the object of so much research amongst collectors, are almost universally printed at Paris.

English Romance. England, so often conquered, yet fated to receive an accession of strength from each new subjugation, cannot boast much of ancient literature of any kind; and, in the department of which we treat, was totally inferior to France. The Saxons had, no doubt, romances (taking the word in its general acceptation); and Mr Turner, to whose researches we are so much indebted, has given us the abridgment of one entitled *Caedmon*, in which the hero, whose adventures are told much after the manner of the ancient Norse Sagas, encounters, defeats, and finally slays an evil being called Grendel, who, except in his being subject to death, seems a creature of a supernatural description. But the literature of the Saxons was destroyed by the success of William the Conqueror, and the Norman knights and barons, among whom England was in a great measure divided, sought amusement, not in the lays of the vanquished, but in those composed in their own language. In this point of view, England, as a country, may lay claim to many of the French romances, which were written, indeed, in that language, but for the benefit of the court and nobles of England, by whom French was still spoken. When the two languages began to assimilate together, and to form the mixed dialect termed the Anglo-Norman, we have good authority for saying that it was easily applied to the purpose of romantic fiction, and recited in the presence of the nobility.

Robert de la Brunne, who composed his *History of England* about this time, has this remarkable passage, which we give, along with the commentary of the Editor of *Sir Tristrem*, as it is peculiarly illustrative of the subject we are inquiring into.

Als thai haf wryten and sayd
Haf I alle in myn Inglis layd,
In symple speche as I couthe,
That is lightest in manne's mouthe.
I made noght for no disours,
Ne for no seggours, no harpours,
Bot for the luf of symple men,
That strange Inglis cannot ken;
For many it ere that strange Inglis,
In ryme wate never what it is;
And bot thai wist what it mente,
Ellis methought it were alle schente.
I made it not for to be praysed,
Bot at the lewed men were aysed.
If it were made in ryme couwee,
Or in strangere, or enterlacé,
That rede Inglis it ere inowe
That couthe not have coppled a kowe.
That outher in cowee or in baston,
Sum suld haf ben fordon;
So that fele men that it herde
Suld not witte howe that it ferde.
I see in song, in sedgeyng tale,
Of Erceldoune and of Kendale,
Non tham sayis as thai thaim wroght,
And in ther saying it semes noght,
That may thou here in Sir Tristrem,
Over gestes it has the steem,
Over all that is or was,
If men it sayd as made Thomas;
Bot I here it no man so say,
That of some copple som is away.
So thare fayre saying here beforne,
Is thare travaile nere forlorne;
Thai sayd it for pride and nobleye,
That were not suylke as thei.
And alle that thai willed overwhere,
Alle that ilke will now forfare.
Thai sayd it in so quaint Inglis,
That many wate not what it is.
Therfore heuyed wele the more
In strange ryme to travayle sore
And my wit was oure thynne;
So strange speche to travayle in;
And forsoth I couth noght
So strange Inglis as thai wroght,
And men besoght me many a tyme
To turne it bot in light ryme.
Thai seyd if I in strange ryme it turn,
To here it many on suld skorne;
For in it ere names fulle selcouthe,
That ere not used now in mouthe.
And therfore, for the commonalté,
That blythely wild listen to me,
On light lange I it began,
For luf of the lewed man.

"This passage requires some commentary, as the sense has been generally mistaken. Robert de Brunne does not mean, as has been supposed, that the minstrels who repeated Thomas's romance of *Sir Tristrem*, disguised the meaning by putting it into '*quainte Inglis;*' but, on the contrary, that Kendal and Thomas of Erceldoune did themselves use such '*quainte Inglis,*' that those who repeated the

story were unable to understand it, or to make it intelligible to their hearers. Above all, he complains that, by writing an intricate and complicated stanza, as '*ryme cowee, strangere,* or *entrelacé,*' it was difficult for the *diseurs* to recollect the poem; and of *Sir Tristrem,* in particular, he avers, that he never heard a perfect recital, because of some one '*copple*' or stanza, a part was always omitted. Hence he argues at length, that he himself, writing not for the minstrel or harper, nor to acquire personal fame, but solely to instruct the ignorant in the history of their country, does well in chusing a simple structure of verse, which they can retain correctly on their memory, and a style which is popular and easily understood. Besides which, he hints at the ridicule he might draw on his poem, should he introduce the uncouth names of his personages into a courtly or refined strain of verse. They were

Great names, but hard in verse to stand.

While he arrogates praise to himself for his choice, he excuses Thomas of Erceldoune and Kendale for using a more ambitious and ornate kind of poetry. They wrote for pride (fame) and for nobles, not such as these my ignorant hearers."*

If the editor of *Sir Tristrem* be correct in his commentary, there existed in the time of Thomas de Brunne minstrels or poets who composed English poetry to be recited in the presence of the great, and who, for that purpose, used a singularly difficult stanza, which was very apt to be mutilated in recitation. *Sir Tristrem,* even as it now exists, shows likewise that considerable art was resorted to in constructing the stanza, and has, from beginning to end, a concise, quaint, abstract turn of expression, more like the Saxon poetry than the simple, bold, and diffuse details of the French minstrel. Besides *Sir Tristrem,* there remain, we conceive, two other examples of "gestes written in quaint Inglis" composed, namely, according to fixed and complicated rules of verse, and with much attention to the language, though the effect produced is far from pleasing. They are both of Scottish origin, which may be explained, by recollecting that in the Saxon provinces of Scotland, as well as at the court, Norman was never used; and therefore it is probable that the English language was more cultivated in that country at an early period than in England itself, where it was for a long time superseded by that of the conquerors. These romances, entitled *Sir Gawain,* and *Sir Gologras,* and *Sir Galeran of Galloway,* have all the appearance of being original compositions, and display considerable poetical effort. But the uncouth use of words dragged in for the sake of alliteration, and used in secondary and oblique meanings, renders them extremely harsh in construction, as well as obscure in meaning.

In England it would seem that the difficulties pointed out by De la Brunne threw out of fashion this ornate kind of composition; and the English minstrels had no readier resource than translating from the French, who supplied their language at the same time with the phrases of chivalry which did not exist in English. These compositions presented many facilities to the minstrel. He could, if possessed of the slightest invention, add to them at pleasure, and they might as easily be abridged when memory failed, or occasion required. Accordingly, translations from the French fill up the list of English romance. They are generally written in short lines rhyming together; though often, by way of variety, the third and sixth lines are made to rhyme together, and the poem is thus divided into stanzas of three couplets each. In almost all of these legends, reference is made to "the romance," that is, some composition in the French language, as to the original authority. Nay, which is very singular, tales where the subjects seem to be of English growth, seem to have yet existed in French ere they were translated into the language of the country to which the heroes belonged. This seems to have been the case with *Hornchild,* with *Guy of Warwick,* with *Bevis of Hampton,* all of which appear to belong originally to England; yet are their earliest histories found in the French language, or at least the vernacular versions refer to such for their authority. Even the romance of *Richard,* England's own Cœur de Lion, has perpetual references to the French original from which it was translated. It must naturally be supposed that these translations were inferior to the originals, and whether it was owing to this cause, or that the composition of these rhymes was attended with too much facility, and so fell into the hands of very inferior composers, it is certain, and is proved by the highest authority, that of Chaucer himself, that even in his time they had fallen into great contempt. The *Rime of Sir Thopas,* which that poet introduces as a parody, undoubtedly, of the rythmical romances of the age, is interrupted by mine host Harry Bailly with the strongest and most energetic expressions of total and absolute contempt. But though the minstrels were censured by De la Brunne for lack of skill and memory, and the poems which they recited were branded as "drafty rhymings," by the far more formidable censure of Chaucer, their acceptation with the public in general must have been favourable, since, besides many unpublished volumes, the two publications of Ritson and Weber bear evidence of their popularity. Some original compositions doubtless occur among so many translations, but they are not numerous, and few have been preserved. The poem of *Sir Eger* and *Sir Greme,* which seems of Scottish origin, has no French original; nor has any been discovered either of the *Squire of Low Degree, Sir Eglamour, Sir Pleindamour,* or some others. But the French derivation of the two last names renders it probable that such may exist.

The minstrels and their compositions seem to have fallen into utter contempt about the time of Henry VIII. There is a piteous picture of their condition in the person of Richard Sheale, which it is impossible to read without compassion, if we con-

* *Sir Tristrem,* Introduction, pp. lxi. lxii. lxiii. lxiv. lxv. Edin. 1804.

sider that he was the preserver at least, if not the author, of the celebrated heroic ballad of *Chevy Chace*, at which Sir Philip Sidney's heart was wont to beat as at the sound of a trumpet. This luckless minstrel had been robbed on Dunsmore Heath, and, shame to tell, he was unable to persuade the public that a son of the muses had ever been possessed of the twenty pounds which he averred he had lost. The account he gives of the effect upon his spirits is melancholy, and yet ridiculous enough.

After my robbery my memory was so decayde,
That I colde neather syng nor talke, my wytts wer so dismayde.
My audacitie was gone, and all my myrry tawk,
Ther ys sum heare have sene me as myrry as a hawke;
But nowe I am so trublyde with phansis in my mynde,
That I cannot play the myrry knave, accordyng to my kynd.
Yet to tak thought, I perseve, ys not the next waye
To bring me out of det, my creditors to paye.
I may well say that I hade but well hape,
For to lose about threscore pounde at a clape.
The losse of my mony did not greve me so sore,
But the talke of the pyple dyde greve me moch mor.
Sum sayde I was not robde, I was but a lyeng knave.
Yt was not possyble for a mynstrell so much mony to have;
In dede, to say the truthe, that ys ryght well knowene,
That I never had so moche mony of myn owene,
But I had frendds in London, whos namys I can declare,
That at all tyms wold lende me cc.lds. worth of ware,
And sum agayn such frendship I founde,
That thei wold lend me in mony nyn or tene pownde.
The occasion why I cam in dete I shall make relacion,
My wyff in dede ys a sylk woman be her occupacion,
And lynen cloths most chefly was her greatyste trayd,
And at faris and merkytts she solde sale-ware that she made;
As shertts, smockys, partlytts, hede clothes, and othar thinggs,
As sylk thredd, and eggyngs, skirrts, bandds, and strings.

From *The Chant* of Richard Sheale,
British Bibliographer, No. XIII. p. 101.

Elsewhere, Sheale hints that he had trusted to his harp, and to the well known poverty attached to those who used that instrument, to bear him safe through Dunsmore Heath. At length the order of English minstrels was formally put down by the act 39th of Queen Elizabeth, classing them with sturdy beggars and vagabonds; in which disgraceful fellowship they only existed in the capacity of fiddlers, who accompanied their instrument with their voice. Such a character is introduced in the play of *Monsieur Thomas*, as the "poor fiddler who says his songs." The metrical romances which they recited also fell into disrepute, though some of the more popular, sadly abridged and adulterated, continued to be published in *chap. books*, as they are called. About fifty or sixty years since, a person acquired the nickname of *Rosewal and Lilian* from singing that romance about the streets of Edinburgh, which is probably the very last instance of the proper minstrel craft.

If the metrical romances of England can boast of few original compositions, they can show yet fewer examples of the prose romance. Sir Thomas Malory, indeed, compiled, from various French authorities, his celebrated *Morte d'Arthur*, indisputably the best prose romance the language can boast. There is also *Arthur of Little Britain*; and the Lord Berners compiled the romance of the *Knight of the Swan*. The books of Amadis were likewise translated into English; but it may be doubted whether the country in general ever took that deep interest in the perusal of these records of love and honour with which they were greeted in France. Their number was fewer; and the attention paid to them in a country where great political questions began to be agitated was much less than when the feudal system still continued in its full vigour.

III. We should now say something on those various kinds of romantic fictions which succeeded to the romance of chivalry. But we can only notice briefly works which have long slumbered in oblivion, and which certainly are not worthy to have their slumbers disturbed.

Pastoral Romance.

Even in the time of Cervantes, the pastoral romance, founded upon the *Diana* of George of Menté Mayer, was prevailing to such an extent as made it worthy of his satire. It was, indeed, a system still more remote from common sense and reality than that of chivalry itself. For the maxims of chivalry, high-strained and absurd as they are, did actually influence living beings, and even the fate of kingdoms. If *Amadis de Gaule* was a fiction, the Chevalier Bayard was a real person. But the existence of an Arcadia, a pastoral region, in which a certain fantastic sort of personages, desperately in love, and thinking of nothing else but their mistresses, played upon pipes, and wrote sonnets from morning to night, yet were supposed all the while to be tending their flocks, was too monstrously absurd to be long credited or tolerated.

Heroic Romances.

A numerous, and once most popular, class of fictions, was that entitled the *Heroic Romance of the Seventeenth Century*.

If the ancient *Romance of Chivalry* has a right to be called the parent of those select and beautiful fictions which the genius of the Italian poets has enriched with such peculiar charms, another of its direct descendants, *The Heroic Romance of the Seventeenth Century*, is, with few exceptions, the most dull and tedious species of composition that ever obtained temporary popularity. The old romance of Heliodorus, entitled *Theagenes and Chariclea*, supplied, perhaps, the earliest model of this style of composition; but it was from the romances of chivalry that it derives its most peculiar characteristics. A man of a fantastic imagination, Honoré d'Urfé, led the way in this style of composition. Being willing to record certain love intrigues of a complicated nature which had taken place in his own family, and amongst his friends, he imagined to himself a species of Arcadia on the banks of the Lignon, who live for love and for love alone. There are two principal stories, said to represent the family history of D'Urfé and his brother, with about thirty episodes, in which the gallantries and intrigues of Henry IV.'s court are presented under borrowed names. Considered by itself, this is but an example of the pastoral romance; but it was so popular that three celebrated French authors, Gomberville, Calprenede, and Madame Scuderi, seized the pen, and composed in emulation many interminable folios of heroic romance. In these insipid performances, a conventional character, and a set of family manners and features, are ascribed to the heroes and heroines, although selected from dis-

Romance || Roscommon.

tant ages and various quarters of the world. The heroines are, without exception, models of beauty and perfection; and, so well persuaded of it themselves, that to approach them with the most humble declaration of love is a crime sufficient to deserve the penalty of banishment from their presence; and it is well if it is softened to the audacious lover, by permission, or command to live, without which, absence and death are accounted synonimous. On the other hand, the heroes, whatsoever kingdoms they have to govern, or other earthly duties to perform, live through these folios for love alone; and the most extraordinary revolutions which can agitate the world are ascribed to the charms of a Mandana or a Statira acting upon the crazy understanding of their lovers. Nothing can be so uninteresting as the frigid extravagance with which these lovers express their passion; or, in their own phrase, nothing can be more freezing than their flames, more creeping than their flights of passion. Yet the line of metaphysical gallantry which they exhibited had its fashion, and a long one, both in France and England. In the latter country they continued to be read by our grandmothers during the Augustan age of English, and while Addison was amusing the world with its wit, and Pope by its poetry. The fashion did not decay till about the reign of George I.; and even more lately, Mrs Lennox, patronized by Dr Johnson, wrote a very good imitation of Cervantes, entitled, *The Female Quixote*, which had those works for its basis. They are now totally forgotten.

The modern romance, so ennobled by the productions of so many master hands, would require a long disquisition. But we can here only name that style of composition in which De Foe rendered fiction more impressive than truth itself, and Swift could render plausible even the grossest impossibilities.

(N. N.)

Situation and Boundaries.

ROSCOMMON, a county in the province of Connaught in Ireland, bounded on the north by Sligo and Leitrim; on the east by the river Shannon, which separates it from Longford and Westmeath; on the south by Galway; and on the west by Mayo. It is of a very irregular form, extending about 60 miles from north to south, at both which extremities its breadth is greatly contracted; from east to west its greatest extent is about 37 miles; and it contains 869 square miles, or 556,847 English acres, divided into six baronies and 56 parishes. Of these parishes, 50 belong to the see of Elphin, and the rest to those of Tuam, Clonfert, and Ardagh. Roscommon, the county town, situated near its centre, is in north latitude 53° 35′, west longitude 8° 8′, about 89 English miles W. N. W. of Dublin.

Extent and Divisions.

Surface.

This is for the most part a flat country; in some places sprinkled with rocks, in many interrupted by extensive bogs; but having few hills, except in its northern quarter, where the Curlew Mountains form its boundary with Sligo. In this quarter, at Arigna, coal and iron-works were carried on a few years ago, but afterwards discontinued. The soil is for the most part rich, incumbent upon limestone, and adapted to either tillage or grazing. The rivers are the Shannon and the Suck. The Shannon flows along the eastern boundary for about 60 miles, and is there navigable for small vessels. In its course it forms several fine lakes, of which the most considerable are Loughs Ree, Baffin, and Allen. The Suck, in like manner, separates this county from Galway on the south and west. Both flow south, and almost parallel to each other, till the Suck, turning to the east, joins the Shannon a little to the north of Clonfert. There are several other lakes, the largest of which is Lough Key, on the north side, distinguished for its beautiful scenery of wooded islands and surrounding groves.

Estates.

Here, as in most parts of Ireland, the estates were once very large; but they have been broken down in some instances, by the granting of leases in perpetuity; a practice which has given rise to a class of landholders, interposed between a few great proprietors on the one hand, and a numerous body of cultivators on the other.

Grazing and Tillage.

Roscommon is chiefly a grazing county, and feeds some of the best long-horned cattle and long-woolled sheep in Ireland, but there are few dairies. During the late war its fine green pastures, under this management, afforded a very ample rent, and tillage was therefore conducted on a small scale; but the plough has been more in request since the peace, both here and in other parts of Ireland; and the soil of such rich grazing lands requiring nothing more than the common operations of tillage to yield large crops, the growth of corn throughout Ireland has been greatly increased. Yet within these few years agriculture was here in a very backward state. "In Roscommon," says Mr Wakefield, "I heard of horses being yoked to the plough by the tail, but I had not an opportunity of seeing this curious practice. I was, however, assured by Dean French, that it is still common with two-year-old colts in the spring." Potatoes, oats, and flax, are the principal crops.

Towns.

There are no large towns here. The principal are, Boyle, Roscommon, the county town, Stokestown, and Elphin, the birth-place of Oliver Goldsmith; none of which are so considerable as to be represented in Parliament; though Roscommon, Boyle, and Tulsk, the latter a wretched village, had each two representatives in the Irish Parliament. The county itself, in which the Catholic interest predominates, sends two members to the Parliament of the United Kingdom. In 1791 the population was estimated to be 86,000, nearly all Catholics; and by the census of 1821 the number is 207,777. The English and Irish languages are spoken in most parts of the county with equal facility.—See the general works quoted under the former Irish counties. (A.)

Population.

Situation and Boundaries.

ROSS-SHIRE, one of the northern counties of Scotland, situated between 57° 8′ and 57° 59′ north

Ross-shire. latitude, and between 4° and 5° 46′ west longitude from Greenwich. Including the small county of Cromarty, which consists for the most part of detached tracts surrounded by Ross-shire, the boundaries are the sea on the east and west, the county of Sutherland on the north, and Inverness-shire on the south. On the east are the Friths of Dornoch, Cromarty, and Moray, arms of the sea which run up into the interior; the latter, the most considerable, washing its south-eastern extremity. The west coast is still more indented with similar, though smaller, inlets, here called lochs; of which the largest are the Great and Little Loch Broom, Loch Groinard, Loch Ewe, Gareloch, where there has long been a regularly productive cod-fishery, Loch Terridon, Lochs Kisserne and Carron, and Loch Duich.

Extent. From north to south Ross-shire extends about 56 miles, and from east to west somewhat more than 70; having an area, according to the latest authorities, of 2129 square miles, or 1,362,560 English acres, without including the island of Lewis, one of the Hebrides belonging to this county, or the space occupied by the county of Cromarty. In the *Agricultural Survey* by Sir George Mackenzie, its extent is computed to be greater by about half a million of acres. Ross and Cromarty contain 33 parishes, of which seven are on the west coast, and four in the island of Lewis. One parish lies within the bounds of the synod of Glenelg, and all the rest in that of Ross. Many of these parishes are very large, but the ministers are assisted in their duties by missionaries maintained by the Royal bounty, and the Society for Propagating Christian Knowledge.

Surface. In the *Encyclopædia* will be found a pretty full description of this extensive district, to which we must refer, and shall notice here only such circumstances as may be necessary to give a general view of its present condition. Excepting a narrow tract on the sea-coast on the east, where the soil and climate are not unfavourable to cultivation, the general character of Ross-shire is that of a rugged mountainous country, interspersed with narrow glens, fresh water lakes, and mountain streams, with here and there fringes of natural wood, and plantations of some extent, and a few gentlemen's seats; but, upon the whole, it is a wild and desolate region, upon which a great deal of rain falls in summer, and snow in winter, the latter lying among the recesses of some of the mountains all the year. Including the woodlands, only about 9 acres in 100 are supposed to be susceptible of cultivation.

Estates. The landed property of Ross-shire, valued in the cess-books at L. 75,043, 10s. 3d. Scots, consisted, in 1811, of 85 estates, of which 50 were under the valuation of L. 500 Scots each, 25 above L. 500, and below L. 2000, and 10 above L. 2000; from which it would appear that they are generally of great extent; the medium size being upwards of 16,000 English acres. But their value is far from being in proportion; the real rent of the lands in that year having been L. 91,089, 18s. 8d., and of the houses L. 2798, 1s. 4d. Sterling; the former affording a mean rental for each estate of not quite L. 1072, or about 1s. 4d. *per* acre.

Seats. The principal seats are Brahan Castle, Stewart Mackenzie; Tulloch Castle, Davidson; Fowlis Castle, Monro, Bart.; Coul, Mackenzie, Bart.; Novar House, Munro, Bart.; Invergordon Castle, Macleod; Balnagowan, Ross, Bart.; Tarbat House, Hay Mackenzie; Geanies House, Macleod; Conan House, Hector Mackenzie, Bart.; Rosehaugh, Roderick Mackenzie, Bart.; Cromarty House, Ross; and Lochalsh, Innes, Bart.

Rural Economy. The occupation of this district in an agricultural view, and the system of management which prevails among the tenantry, do not differ materially from what we have already described under Inverness-shire and the other Highland counties of Scotland. The native farmers hold a few acres of arable land, with grazings commonly contiguous, but in some cases at a distance;—raise oats, bear or big, and potatoes; and keep a great many cattle and horses, which are always stunted in their growth for want of food, and in severe winters many of them perish. Except in seed-time and harvest, and while they are preparing peat for their winter's fuel, the tenants spend much of their time in idleness, or in the practice of illicit distillation among their hills, though in some parts, particularly on the west coast, also in fishing; and their labour, and that of their cattle, is, generally speaking, irregular and unproductive. Several of the proprietors, however, and some farmers brought hither from other counties, conduct their farming operations upon the most approved system; and upon the east coast all the crops grown in Scotland may be seen under excellent cultivation. Sheep-farming, too, notwithstanding the opposition of the small tenants, has been introduced into this as well as most of the other Highland counties. Leases for nineteen years have become common here as in other parts of Scotland.

Towns. The towns are Dingwall, at the bottom of the Frith of Cromarty, Fortrose, Tain, on the south coast of Dornoch Frith; all royal burghs, but very small places, and situated on the east side of the county. On the west, the only place of any consideration is the village of Ullapool, on the banks of Loch Broom, built within these thirty years by the British Society for extending the Fisheries, &c. at an expence of upwards of L. 20,000. But the herring-fishery on this coast, always precarious, having failed for several years in succession, the inhabitants have been often reduced to great distress, and notwithstanding every encouragement, many have abandoned it. It remains to be seen whether the recent repeal of the salt duties may not lead to a more spirited and successful prosecution of the fisheries, so much to be desired for the employment and subsistence of the people of this and other parts of the Highlands, who are by far too numerous to be employed beneficially in agriculture. Even the loch-fishings, hitherto much neglected, might be rendered a valuable resource in this respect.

Tar from the roots of Fir-trees. There is scarcely any thing in Ross-shire that deserves the name of a manufacture, except one of a somewhat peculiar description, and which may be worth notice for that reason. We allude to the practice of obtaining tar, so necessary for the sheep-stocks of the county, and other purposes, from the roots and trunks of the fir-trees found in the mosses. These mosses, which are of great extent here, as

Ross-shire || Roxburghshire.

well as in many other parts of Scotland, so generally abound in such materials, that Sir George Mackenzie thinks that more tar might be thus procured than would suffice for home consumption. From these roots the Russians extract considerable quantities of turpentine by a very simple and unexpensive process, described by Dr Howison in a recent communication to the Highland Society of Scotland.

Representation. Ross-shire, which has about 90 freeholders, sends one member to Parliament; and in the elections for the Scottish burghs, Dingwall and Tain are associated with Dornoch, Wick, and Kirkwall, and Fortrose with Forres, Nairn, and Inverness. The jurisdiction of one sheriff extends over this and the shire of Cromarty; and his substitutes hold their courts at Tain, Dingwall, and Fortrose, for the mainland of the county, and at Stornoway, in Lewis, for the islands politically attached to it. Population. The population of the two counties of Ross and Cromarty, according to the census of 1801, was 52,291; in 1811 it amounted to 60,853; and in 1821 to 68,828, of which 32,324 were males, and 36,504 were females. The *families* employed in agriculture were 7947; in trade and manufactures 3356; in other occupations of various kinds 3203. The increase of population from 1811 to 1821 was 13,485.

See the general works quoted under the former Scottish counties, and Sir George Mackenzie's *General View of the Agriculture of the Counties of Ross and Cromarty*. Also the article CROMARTY in this *Supplement*. (A.)

Situation and Boundaries. ROXBURGHSHIRE, a county in Scotland, on its south-eastern extremity, where it meets with England, situated between 55° 6′ and 55° 43′ north latitude, and between 2° 12′ and 3° 7′ west longitude from Greenwich. It is sometimes called Teviotdale, from its principal river the Teviot, but improperly, as it also includes a tract called Liddesdale on the south-west, which is unconnected with the Teviot. Its boundaries are Berwickshire, from which it is separated in part by the river Tweed, on the north; Selkirkshire and Dumfries-shire on the west, and south-west; and the English counties of Cumberland and Northumberland on the south-east and east. Between Berwickshire and Selkirkshire, a small tract touches the county of Mid-Lothian; on the south, between Dumfries-shire and Cumberland, the county terminates almost in a point; on the west it surrounds small portions of Selkirkshire in some places, and in others projects into that county; and it has the Cheviot hills on the east; the outline being exceedingly irregular on all sides. According to the latest authorities, its area is 715 square miles, Extent. or 457,600 English acres; containing 30 entire parishes, and part of other four, which properly belong to the counties adjoining. For the purposes of justice and police, Divisions. it is divided into the four districts of Kelso and Jedburgh on the east, and Melrose and Hawick on the west. In an agricultural view, it may be considered as divided into arable land and hilly pasture; the pasture land, estimated at about $\frac{2}{3}$ths of the whole, occupying the eastern, southern, and western quarters, and surrounding, in a circular form, the arable, which lies on the north and north-east sides of the county.

Surface. Except upon the banks of the streams, which are commonly of no great width, there is very little level or flat land in this district; and, compared with the high grounds in other parts of Scotland, hardly any part of it can be said to be mountainous. The cultivated districts are beautifully diversified with narrow valleys, each traversed by its own rivulet, often fringed with wood, and bounded by gentle acclivities; and the hills in pasture are, with few exceptions, clothed in verdure to their very summits. On the confines of Northumberland, the most elevated quarter, the hills seldom reach the height of 2000 feet, but there are many from that height down to 800 or 1000 feet. The most considerable are Minto and the Eildon hills, both in the arable division; and Dunion, Ruberslaw, Wisp, Hownam Law, Millenwood-Fell, Carter-Fell, and Chillhill, in the pastoral districts. Most of them having a conical form, insulated at their base by streamlets, and not rising in a continuous range, present very conspicuous objects, and at a distance seem higher than they are found to be when approached. The beauties of the natural scenery have, over all the lower grounds, been heightened and improved by the wealth and industry of its inhabitants; all this division abounding in gentlemen's seats, comfortable, and sometimes elegant farm-houses; the fields inclosed with hedges of thorn, and belts of wood, and many spots covered with young trees. On the skirts of the hills, too, cultivation has made considerable progress of late, as much, perhaps, as could be expected in the natural circumstances of the country; but the interior of the pastoral district is in general naked, without trees or fences, and very thinly inhabited.

Soil. The prevailing soil of the arable land, and over most of the hills, is what is called a sandy loam, though of different qualities, excellently adapted to the turnip culture. Tracts of a clayey or more heavy soil, however, occupy a considerable space, especially on the north-west. Clay is also found on the north, near the Tweed, where it is rich and fertile. Moss, marsh, and heath, occur in the south-west, and occasionally in other quarters; but altogether they cover but a small proportion of the surface.

Rivers. No district in Britain is better supplied with streams, though it has only two that deserve the name of rivers, the Tweed and the Teviot. The Tweed, which crosses the north part of the county, and for part of its course forms the boundary with Berwickshire, enters it from Selkirkshire, on the north-west, and leaves it below Redden on the north-east; carrying with it nearly all the waters that pass through, or have their source in, this district. Its banks, especially near Kelso, where it is crossed by an elegant bridge, built about 20 years ago, are perhaps equal in richness and beauty to those of any river of the same extent in Britain. The Teviot more properly belongs to this county; rising and terminating within its bounds. It has its source in the south-west extremity, near the confines of Dumfries-shire, and flowing north-east almost through the middle of the district, joins the Tweed, in which its name is lost, a little above the town of Kelso. From Hawick downwards it is a considerable stream, and,

Roxburghshire.

like the Tweed, flows through a very fertile and well cultivated country. The principal rivulets that fall into the Teviot from the south are Allen, Slittrick, Rule, Jed, Oxnam, and Kale; and from the north and west, Borthwick and Ale. The Liddel and Hermitage, which run on the south-west, and whose united streams retain the name of Liddel, from which this tract is called Liddesdale, soon leave Roxburghshire; and after forming the boundary between Dumfries-shire and Cumberland, fall into the Esk above Longtown. The other streams are the Etterick, which joins the Tweed from the south-west as it enters this county; another Allen and the Leader, which fall into the same river from the north; and the Eden, which, after an easterly course, partly on the boundary with Berwickshire, enters the Tweed on the north-east, a little before it leaves the county. The Beaumont also rises here among the Cheviot hills on the east, but after a short course, passes by Kirkyetholm, and enters Northumberland. Of the smaller streams, the Ale, Jed, Rule, and Hermitage, are distinguished for their natural scenery; to which we may add the Liddel, celebrated by the late Dr Armstrong, a native of Liddesdale. Tweed is the only river frequented by salmon, except at the time of spawning, when they are found in most of the other streams. Trout abounds in the Ale, Rule, Jed, and Kale, and there are a few small lakes which contain perch and pike.

Minerals.

Roxburghshire is not rich in minerals. Coal has been found on the Carter Hill, near the borders of Northumberland, and in the southern extremity of Liddesdale. It is worked at the latter place, but this is too remote to render it of much value to the inhabitants of this county, who are chiefly supplied with coal from Northumberland. Limestone, which abounds in various parts, is not wrought to any extent, owing to the want of coal. There are excellent sandstone quarries at Sprouston on the Tweed, and marl in several parishes, particularly at Eckford, on the Teviot, and Ednam, near the Tweed. But the use of marl as a manure is confined to a narrow circle around the places where it is found; lime, of which a much smaller quantity answers the purpose, being most in request; and the lime is almost all like the coal brought from Northumberland, from 20 to 30 miles distant from many parts of the arable district.

Valuation and Rental.

The valued rent of Roxburghshire is L. 314,663, 6s. 4d. Scots, being next to Fife and Perth, the highest in Scotland; and the real rent of the lands, in 1811, was L. 230,663, 9s. 9d. Sterling, and of the houses L. 11,508, 6s. 3d. It is one of the few counties where the rent in Sterling falls below the valuation in Scots money; a circumstance which is certainly not owing to the want of improvements to sustain rent, nor to the present rents being too low; but to the mistaken vanity of its land owners, whose rent-rolls at the time of the valuation are understood to have been stated too high.

Estates.

Of this valuation, which in 1811 was divided among 349 estates, about one-third belongs to lands held under entail, and more than two-thirds to families of the name of Kerr, Scott, Elliot, and Douglas. The principal proprietors are the Dukes of Roxburgh and Buccleuch, and the Marquises of Lothian and Tweeddale; but there are 33 estates in all that have a valued rent of upwards of L. 2000 Scots each; and 55 more are from L. 500 to L. 2000. Yet moderate and small properties are very numerous; the remaining 261 estates being under L. 500 Scots. Several of these exceeding a valuation of L. 400 Scots, and held of the Crown, have been acquired by professional farmers, who have thus become freeholders, and enjoy a share of political influence. Among the seats in the county, which are too numerous to be mentioned here, the most splendid is Fleurs, the mansion of the Duke of Roxburgh, beautifully seated at the confluence of the Tweed and Teviot, near Kelso.

Farms.

Roxburghshire is divided, for the most part, into larger farms, if we except a few sheep farms in the Highlands, than any other county in Scotland; many of them, consisting of land partly arable and partly pasture, being from 1000 to 3000 acres; and several of these, in some instances, are in the occupation of one tenant. Farms altogether arable, containing from 500 to 1000 acres, are not uncommon. The capital and knowledge required for conducting concerns so extensive entitle such men to suitable accommodations in their houses and farm-offices, many of which are accordingly laid out and constructed in a superior style. Most of the farm servants are married and live in houses apart, set down together in some convenient quarter of the farm, each having a small garden attached. It is the practice here, as in other parts of the lowlands of Scotland, to pay most of their wages in the produce of the farm, and not in money; every married ploughman, or *hind*, getting a certain quantity of corn, a cow kept, and some land allowed for potatoes, and often also for flax: he is also commonly allowed to keep a pig and a few hens. Whatever may be the fluctuation of the markets, these labourers are thus always provided with the necessaries of life; and the sale of the butter made from their cow, with its calf, and the eggs of their poultry, and, if the family be not large, a part of their corn, supplies them with the other articles they need; while they fatten their pigs, and work up the flax for the use of their families. No class of men of their rank are to be compared with these hinds for propriety of conduct and frugality; and few of the labouring classes any where are so comfortable and contented with their condition. The practice of paying wages in kind is not, it must be admitted, free from objections; a little pilfering is sometimes detected on the one hand, and a hard master, on the other, may be willing to pay in produce of an inferior quality; but after all, the long experience that has been had of this system over five or six of the principal agricultural counties of Scotland, and the north of England, warrants us in asserting that it works well for both parties, and might have some effect in keeping down poor rates if it prevailed more generally among our southern neighbours.

Rotation of Crops.

On the best soils, the rotation of crops is very simple, corn being taken every second year with a green crop intervening; but, in general, the land does not admit of such constant tillage, and two-fifths, or a half, is commonly in pasture from seeds. Un-

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der a six years' course, the most profitable on rather weak soils, and in a district where there are no large towns to furnish manure, the rotation from pasture is oats, turnips, barley or wheat, clover and rye-grass, partly cut for hay the first year, but chiefly pastured with sheep, and then continued in pasture two years longer. Under this system the crops are almost always good, and the land, instead of being exhausted, is kept in a state of progressive improvement. Though little of the soil be naturally adapted to wheat, yet this grain is now raised to a great extent on all the better descriptions of sandy loam; generally after turnips eaten on the ground by sheep, which, by their treading, give consistency to the soil, as well as leave it greatly enriched by their manure. Only a small part is under beans, somewhat more under pease; barley has in many instances been superseded by wheat; so that wheat and oats are the principal crops of grain; while, whatever be the number of acres in corn, nearly half the quantity is allotted to turnips, and the other half to clover and rye-grass. Potatoes occupy but a very small part of every farm; and flax, where raised at all, is only in small patches for the use of the farm servants. The turnip crop, however, has been lately attacked with a disease which has already begun to make some alteration in the system, leading to the more extensive culture of potatoes, and also of cabbages. This disease, which has been long known in England, but which was a stranger in this and other parts of Scotland 10 or 12 years ago, popularly known by the name of *fingers and toes*, converts the bulb of the turnip, when one has been allowed to form, into a shapeless and morbid mass which no animal will eat, and becomes putrid, and disappears altogether on the first approach of frost. It often prevails over extensive fields, while others adjoining escape; and it seems to make no difference whether the land be fresh from pasture or has been long in tillage.

Sheep and Cattle.

The pastoral district of this county is occupied with an excellent breed of sheep called *the Cheviot*, from the general name of the hills on which they feed; for an account of which breed we must refer to the Article AGRICULTURE in this *Supplement*. On the arable farms, the short-horned cattle and Leicester sheep, neither of them, however, always in a pure state, form the principal stock; and, as so large a proportion of even the arable land is always in grass, the number of both is very great. By means of turnips, most of the disposable stock, whether of cattle or sheep, are carried forward till they are ready for the butcher; when the far greater part is sent to the weekly market of Morpeth in Northumberland, for the consumption of Newcastle and other towns in the north of England.

The progress which agriculture has made in this district has not been favoured by its situation in respect to markets. It has no large towns, and comparatively a small population. Most of the corn, as well as live stock, must, therefore, be carried out of the county; and Berwick-upon-Tweed, the nearest seaport, is upwards of 30 miles from much of its corn lands.

Towns and Manufactures.

The towns are Kelso, Jedburgh, Hawick, and Melrose; and of the villages the most considerable are Yetholm and Kirkyetholm, near its eastern boundary. Kelso, pleasantly situated on the north bank of the Tweed, is a well built, cleanly, and cheerful place, containing near 5000 inhabitants, the capital of this and the adjoining county of Berwick. Some branches of the leather and woollen manufacture, and that of thread, have been long carried on here, with a considerable brewery. Jedburgh, the county town, situated on the rivulet Jed, in the interior, though a place of note formerly, has been long stationary, if not declining. Hawick, which stands on the Teviot, at the point where it is joined by the Slittrick, is a more thriving place, and has manufactures of carpeting, stockings, and other sorts of woollen goods. Melrose, near the south bank of the Tweed, about 10 miles west from Kelso, is no otherwise distinguished than for its abbey. (See MELROSE in the *Encyclopædia*.) The two Yetholms are worthy of notice for their fairs, at which a great part of the cattle, sheep, and wool, of the county are sold; and Kirkyetholm for being the residence of gypsies, and their principal colony in Scotland. Roxburgh, which gives its name to the county, and whose castle was of such importance in the wars between England and Scotland, has long since ceased to exist, and has left no trace of its former consequence. At Jedburgh, Kelso, Melrose, and the village of Gattonside, there are some valuable orchards, particularly at Jedburgh and Melrose, where some very old trees which belonged to their abbeys are still remarkably prolific.

Antiquities.

This county, placed on the borders of the two kingdoms, the scene of frequent warfare and depredation, presents the ruins of a great many castles and towers, and other remains of an early age. It was also distinguished for its religious buildings, of which there are still magnificent remains at Kelso and Jedburgh, as well as at Melrose.

Representation.

Roxburghshire, which has about 140 freeholders, sends one member to Parliament; and Jedburgh, its only royal burgh, joins with Lauder, Haddington, Dunbar, and North Berwick, in electing another for the Scottish burghs. This is one of the few Scottish counties in which there are regular assessments for the poor; and, not many years ago, it presented the still greater anomaly of a Scottish clergyman drawing tithes in kind.

Eminent Men.

Among the eminent men to whom this district has given birth are Thomson, Armstrong, Lord Kames, Elliot, the brave defender of Gibraltar, Leyden, Park, the African traveller, and William Dawson, the father of the improved agriculture of Scotland.

Population.

The population, according to the census of 1801, was 33,682; in 1811 it amounted to 37,230; and in 1821 to 40,892, of which 19,408 were males, and 21,484 were females. The *families* employed in agriculture were 3613; in trade and manufactures 2822; in all other occupations 2204. The increase of population from 1811 to 1821 was 7210.

See the general works quoted under the former Scottish counties, and Douglas' *General View of the Agriculture of Roxburghshire*. (A.)

RUMFORD (COUNT). See THOMPSON (SIR BENJAMIN).

Rush.

RUSH (Benjamin), a celebrated American physician, born, 5th January 1745, near Bristol in Pennsylvania, was descended from a family who were originally Quakers, and who had accompanied Penn, in 1683, to his infant colony.

He lost his father at an early age, and having been first placed by his mother at a school kept by the Rev. S. Finley, he proceeded to finish his classical education at the College of Princeton, and there took a degree of Bachelor of Arts before he was sixteen. He then determined to make the profession of physic the pursuit of his life, and went to study it, first under the care of Dr Redman of Philadelphia, and then at Edinburgh, where he was created a Doctor of Physic in 1768. At the time of his return from Europe, a new school of medicine was about to be founded in Philadelphia, and he became Professor of chemistry immediately upon his arrival. In 1776, he began to take an active part, with the rest of his countrymen, in the political struggle of the day, and he was chosen a member of Congress for the state of Pennsylvania; in 1777 he was appointed Surgeon General to the army, and not long after became Physician General: he also contributed his best efforts to the improvement of the internal government of the state which he represented. But he soon withdrew his attention from political affairs, in order to devote it exclusively to medical and literary subjects, and he continued to be actively engaged in the practice of physic for the remainder of his life.

In 1776 he married Miss Julia Stockton of New Jersey. He had by her thirteen children, nine of whom survived him in respectability and prosperity. In 1791, when the two medical colleges of Philadelphia were incorporated into a single university, he was appointed Professor of the Institutes of Medicine, and of Clinical Practice. In 1793, he greatly distinguished himself by the new and apparently successful modes of practice that he introduced in the epidemic yellow fever, which was then causing great mortality throughout the United States; and which, shortly before his death, he was induced to believe not contagious, but derived from some general causes independent of the previous existence of the disease. He died on the 13th of April 1813, after an illness of five days, of a typhous fever, with some pulmonary symptoms. He had for a considerable part of his life been threatened with consumption, but had combated its attacks with unusual success. The number of his writings is considerable in proportion to their bulk; the times and the state of society in which he lived being such as to produce rather hasty and spirited than highly finished compositions.

1. His inaugural dissertation was entitled *De Concoctione ciborum in ventriculo*, and contained an explanation of the opinions relating to digestion, which he had learned from Dr Cullen. Edin. 1768.

2. *Account of the Effects of the Stramonium.* Amer. *Phil. Trans.* I. 1770.

3. *On the Utility of Wort in ill-conditioned Ulcers. Med. Obs.* Inq. IV. 1770; addressed to Dr Huck.

4. *Inquiry into the Natural History of Medicine among the Indians of North America*, an anniversary oration delivered in 1774.

5. *Remarks on Bilious Fevers*, addressed to Dr Huck. *Med. Obs.* Inq. V.

6. *Account of the Influence of the Revolution on the Human Body: with Observations on the Diseases of Military Hospitals.*

7. *Inquiry into the Cause of the Increase of Bilious and Intermitting Fevers in Pennsylvania. Am. Trans.* II.

8. *Observations on Tetanus.*

9. *Inquiry into the Influence of Physical Causes upon the Moral Faculty.*

10. *Remarks on the Effects of Ardent Spirits upon the Body and Mind.*

11. *Inquiry into the Causes and Cure of Pulmonary Consumption*, in his *Medical Inquiries and Observations*, I. Phil. 1788. His grand object, in the cure of consumption, is to recommend exercise, and every thing which will enable the patient to take exercise; anticipating a practice which has become somewhat fashionable in England of late years, from its frequent success as a temporary palliative. The subject is continued in the second volume of the *Inquiries*, published in 1793; and bleeding is very strongly recommended in the earlier and only curable stages. Consumption, he observes, is common in America, though scrofula scarcely ever occurs; and it has sometimes been known to be clearly communicated by infection to the negroes belonging to a family, who had, of course, no consanguinity that could account for a similarity of constitution. Five volumes, in the whole, of this collection appeared from 1788 to 1798; a second edition was published, in four volumes 8vo, 1804; a third in 1803, revised and enlarged, with a continuation of the *Histories of the Yellow Fever from* 1793 *to* 1809; *a Defence of Bloodletting, as a Remedy for certain Diseases; A View of the State of Medicine in Philadelphia; An Inquiry into the Sources of the usual Forms of Summer and Autumnal Diseases in the United States;* and the recantation of his opinion of the contagious nature of the yellow fever already mentioned.

12. *Information to Europeans disposed to Emigrate to the United States*, in a Letter to a Friend.

13. *Observations on the Population of Pennsylvania.*

14. *Observations on Tobacco.*

15. *A New Mode of Inoculating Small-Pox*, a Lecture. Reprinted. 8. Phil. 1792.

16. *Essay on the Study of the Latin and Greek Languages, American Museum;* condemning it as a waste of time, oppressive to the poor dunces who are tortured into their parts of speech, to the great scandal of a humane and republican country, and subversive of a proper respect for the rights of boys and, consequently, for the rights of man.

17. *Essays, Literary, Moral, and Philosophical*, 8vo. 1798: containing a republication of the last article, together with the author's *Eulogiums* on Dr Cullen and on Professor Rittenhouse, delivered in 1790 and 1796, and with some other miscellaneous papers of less moment. Ed. II. 1806.

18. *Lectures on the Cause of Animal Life*, 1791.

19. *Account of the Sugar Maple Tree. Am. Tr.* III. 1791.

20. *Observations on the Black Colour of the Negro.*

Am. Tr. IV. 1792; attributing the blackness to leprosy.

21. *History of the Yellow Fever.* 1794. This celebrated work has been translated into French and Spanish; at the time of its publication, an almost superstitious dread was entertained by medical men of the use of the lancet in idiopathic fever; and few books have ever had so powerful and extensive an effect in altering the general treatment of a disease as this history had produced in every part of the world; probably, indeed, it may have carried a number of the younger and bolder practitioners into an opposite extreme; but, with respect to the author's claims to merit on the occasion, it must be allowed that the innovation showed an uncommon combination of courage, with talent and good sense; and the accurate description of the disease, that he has given us, fully establishes his claim to the character of an accurate nosologist.

22. *On the Symptoms and Cure of Dropsy, and especially of Water in the Head.* 1793.

23. *An Account of the Influenza of Philadelphia in* 1789, 1790, 1791.

24. *Observations on the State of the Body and Mind in Old Age.* 1794.

25. *Observations on the Nature and Cure of Gout and Hydrophobia.* 1797.

26. *Inquiry into the Cause and Cure of the Cholera Infantum.* 1797.

27. *Observations on Cynanche Trachealis.* 1797.

28. *Introductory Lectures.* 1801. Ed. 2. 1811; with ten new introductory lectures, and two lectures on the Pleasures of the Senses and of the Mind.

29. In 1809, he published the works of Sydenham and of Cleghorn, with *Notes*, and in 1810 those of Pringle and Hilary.

30. *On Diseases of the Mind.* 8. 1812; an elaborate work, which had long been impatiently expected.

31. *A Letter on Hydrophobia.* 1813; addressed to Dr Hosack, and containing additional reasons for believing the seat of the disease to be chiefly in the blood vessels; an opinion which, in all probability, has at least tended to shorten the sufferings of several individuals on whom the experiment of profuse depletion has been tried.

Rush || Russian Empire.

Dr Rush's numerous publications obtained him many marks of respect from his contemporaries, and procured him admission, as an honorary member, into the most distinguished literary and philosophical societies of Europe. His name was familiar to the medical world as the Sydenham of America; his accurate observations and correct discrimination of epidemic diseases well entitled him to this distinction; while, in the original energy of his reasoning, he far excelled his prototype. His literary and professional character, indeed, appears to have been greatly influenced by the moral and political sentiments which were prevalent in his day. A love of innovation led him to that proud defiance of established authority which is just as likely to be pernicious as to be salutary. The study of the learned languages he depreciated, in one of his early essays, as unfit for a republican education; and this was the first step to the true Jacobin doctrine, that it was unrepublican and aristocratical to have received any education whatever. In physic, his rejection of the prejudices of antiquity was somewhat more consistent with moderation, and the reform that he attempted was occasionally more successful than his literary speculations; nor can it be denied that there are a multitude of original suggestions in his works, which may very probably be found capable of affording valuable hints to the lovers of medical experiments.

Hosack and Francis in the *Amer. Med. Philos. Register.* Chalmers's *Biographical Dictionary*, XXV. 8. Lond. 1816. (A. L.)

RUSSIAN EMPIRE.

The Article Russia in the *Encyclopædia* appears to have been drawn up with attention, and, as far as it was founded on the documents collected by Mr Tooke, with accuracy; but the changes that have taken place, and the additional information that has been communicated, render it necessary to give some account, in this place, of the present state of the empire. The principal changes in Europe have arisen from the possession of Finland, and the erection of Poland into a kingdom under the control of Russia. In Asia, some additions of territory have been gained from Persia and Tartary. In America, settlements have been established on the north-west coast of that continent, and claims have been made to some extensive tracts of country which are supposed to conflict with the rights of Great Britain, of the United States of America, or of Spain.

General View of the Russian Empire.

Bounds. Extent.

The Russian dominions, including Poland, form a connected territory, extending from the frontiers of Germany and Prussia eastward to the sea which divides America from Asia, and beyond that, on the continent of America, to an extent hitherto undefined, and which is likely to become the subject of discussion with the other powers established in that division of the globe. Its most western point is in longitude 18° 6′, and its most eastern in 202° 26″ east from London. Its northern and southern boundaries have deep indentations; the extreme points of the former are in 78° north latitude, and of the latter 39° 50′. The extent of this empire has been calculated by different writers with considerable variations. Some have included the mountains of Caucasus, others the whole of the Caspian Sea; whilst some, again, have omitted the

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one and not the other. The comparative results of the several calculations, and the modes by which they have been conducted, lead to the conclusion, that an extent of 7,350,000 English square miles, or 4,704,000,000 acres, is the nearest approximation to accuracy. The whole of China is not equal to two-thirds of Russia; and the Roman Empire, at the period of its greatest extension, did not comprehend more than one-fourth of the territory now subject to that power.* The extent of the European portion of her dominions is only calculated at about one-fifth part of the whole.

Population.

The increase of population in Russia appears to have been equal to that of any other European country. The accounts were very imperfectly kept before the year 1796, as neither the females nor the privileged classes were noticed. By estimates, founded upon the return of taxable males, the inhabitants were calculated to have been, in 1723, 11,736,676; in 1743, 13,653,191; in 1763, 17,886,139; and in 1783, 25,482,214.

The *Memoirs* of the Academy of Petersburg give the population of the following years till 1805, thus:

Year.	Population.
In 1800	33,159,860
1801	34,043,357
1802	34,893,828
1803	35,134,177
1804	36,043,483

In these accounts, the inhabitants of Moscow and Petersburg, the military and their families, and the wandering tribes, amounting to 2,900,000 persons, were not included. With the addition of those classes, the result of the calculation gave, as the whole number of inhabitants, 41,253,483.

The following Table is formed from the reports published by the Synod (which, however, includes only the members of the Orthodox Greek church), and shows the rate of the progressive increase of the population, as far as relates to that most numerous proportion of the people.

	1806.	1810.	1816.	1820.
Marriages	299,057	320,389	329,683	317,805†
Births	1,361,286	1,374,926	1,457,606	1,570,399‡
Deaths	818,585	903,380	820,383	917,680§
Deaths of Persons above 100 years old	293	350	689	807

Taking the account of the population, as stated before, to have been in the year 1806 -	41,253,483
And inferring an annual increase by excess of births over deaths at 500,000 from 1806 to 1822, being 16 years, or - - -	8,000,000
And for acquired territory, viz.	
in 1807, Bialystock, - -	219,050
1809, Finland, - -	1,101,898
1812, Caucasus provinces, -	120,000
—— Moldaw and Bessarabia,	310,000
1815, The portion of Poland,	3,472,500
We estimate the inhabitants of this empire - - -	54,476,931

This vast population consists of several distinct races, which have been classed and calculated by several different writers under the following heads:‖

Different Races.

1st, *Sclavonians*. These, comprehending the inhabitants of Russia, Poland, Lithuania, and Courland, are estimated at 44,930,000.

2d, *Fins*. These consist of the chief residents of Finland, Livonia, Lapland, and some other tribes, which together amount to about 2,360,000.

3d, *Tartars*. They comprehend several tribes, and a great number of subdivisions of tribes. The Tartars proper are divided into fourteen different branches; the Noggiers into six; besides which are the Kirgusiens, the Aralians, the Chewensens, the Bucharens, the Bashirs, the Teleutes, and the Jakutes, who are taken together at 1,800,000.

4th, The *Caucasians*, which comprehend the Ischerkessens, the Awcheses, the Lesghies, the Ossetts, and Kistenses, estimated at 1,300,000.

5th, *Monguls*. Under this head are comprehended the Monguls proper, the Calmucks, the Buritens, and the Kuriles, supposed to amount to 350,000 only.

6th, The *Mandshurs*, in two branches, viz. Tungusens and Lamutes, whose numbers do not exceed 80,000.

7th, *Polar People*, comprehending Samoiedes, Korjacks, Ostjacks, Kamschats, and some smaller tribes, whose whole numbers are not more than 300,000.

8th, The *Colonists*. These include the various foreigners established in the empire with peculiar rights. The Jews amount to about 500,000; the Germans to 250,000; and the other Europeans and Asiatics to about 750,000; making together, under this head, 1,500,000.

Religion.

The comparative religious classes in the Russian dominions have been recently stated as follow:

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* See Kraft, *Sur la Surface Geometrique de la Russie*. *Novis Act. Petersb.* T. I. p. 389—400.

† It appears that the marriages in 1820 were fewer by 22,470 than in the year 1819.

‡ The births of 1820 exceeded those of 1819 by 48,265.

§ The deaths of 1820 were fewer than those of 1819 by 1429.

‖ J. B. Georgi *Beschreibung aller Nationen des Russischen Reichs*. Hempel's and Geisler's *Abbildung und Beschreibung der Völker anter Alexander*. *Le Peuples de la Russie*, par le Comte Ch. de Rechberg.

Russian Empire.

Orthodox Greek Church,	40,351,000	
Catholics and United Greeks,	5,990,000	
Lutherans,	2,400,000	
Reformed or Calvinists,	82,800	
Armenians,	63,000	
Hernhuters,	9,200	
Mennonites,	6,000	
Christians,		48,902,000
Mahomedans,		3,100,000
Jews,		500,000
Worshippers of the Grand Lama,		300,000
Schamans or Heathens,		600,000
		53,402,000

The people of Great and Little Russia, the Cossacks, the Greeks, Arnauts, Walachians, Moldavians, and Bulgarians, adhere to the Greek church. The Catholics are chiefly in Poland and Lithuania, and among the colonists. The Lutherans are to be found mostly in Finland, Courland, and Esthonia, and among the German colonists. The Armenians are mostly in the southern part of the Asiatic division of Russia, in the vicinity of Astrachan. The Calvinists, Hernhuters, Mennonites, are all colonists, except a few in Poland. Tartary contains chiefly Mahomedans. Schamanism or idolatry is practised by the Samoiedes and other Polar tribes.

All religious sects, whether Christians or others, enjoy equal civil rights; and the same protection in the exercise of their various modes of devotion. The predominant party, the Greek church, possess about 70,000 places of worship, which are served by about 160,000 secular clergy. There are 480 monasteries, and 156 nunneries, under the direction of the regular clergy. The whole are governed by a Consistory, of which the Emperor is perpetual president, and which is divided into three departments; and these again into thirty-six sections or dioceses. The learning of the inferior clergy is very inconsiderable; many of them can merely repeat by rote a few established prayers, can scarcely read, and much less write. They are allowed to marry once, but not after becoming widowers. Their sons must all be devoted to the ecclesiastical profession. They are generally paid small stipends by the government; but some few of them enjoy landed property attached to their benefices. A few men of learning are to be found among the higher ranks of the clergy; but their number and acquirements have never been very distinguished.

The Catholic church, governed by a Consistory, comprehends one archbishopric, six bishoprics, and about forty religious establishments belonging to the several orders of Benedictines, Franciscans, Carmelites, Bernardines, and Trinitarians.

The Lutherans, established in Finland, in Courland, and Livonia, are under the superintendence of their respective Consistories, each of which has a bishop as their president.

The other religious Christian denominations are rather voluntary associations, recognized by the state, than, properly speaking, established ecclesiastical communities.

Few of the Mahomedans are very rigid in their adherence to the regulations of their prophet. They have colleges for education; several mullahs, and two muftis. The mufti of Ufa enjoys a stipend of 1500 roubles from the crown, and has two mullahs in Casan. The mufti of Taurus has joined with him a cadi, an effendi, and five ulemas, who regulate religious affairs, and administer the laws in that province.

The worshippers of the Grand Lama have their principal religious establishment at Darsan, in the province of Udinsk. Their priests are numerous, and, in the province of Irkurzk alone, are said to be near 300, where they are very successful in making converts among the wandering tribes.

Different Ranks or Classes.

The inhabitants of Russia are divided into the following classes or ranks; for though all offices are equally open to every description of subjects, yet exclusive privileges are enjoyed by some numerous bodies.

Nobles.

The Nobles in Russia, though distinguished by the several titles of prince, count, or baron, are all upon an equal footing, and enjoy equal privileges. Their persons and lands are freed from taxation; they are exempted from the recruiting ballot; and are not subject to bodily penalties. These exemptions are, however, more apparent than real; for though their lands and persons are not taxable, yet a capitation tax, at the will of the government, may be imposed on their slaves, who form the most valuable part of their possessions. Though not in person compelled to serve in the army, yet they are bound to furnish from their slaves a number of recruits in proportion to the demands of the service. In some of the more recently acquired provinces, such as Livonia, Esthonia, and in Poland, the nobles have, or rather exercise other privileges, extending even to the power of life and death, over their vassals; but these powers arise from custom and general acquiescence much more than from the existing law.

Clergy.

The Clergy are exempt from taxation, and from corporal punishment; which privileges are extended to each eldest son, who must, however, though his father is excused, take the risk of being called upon for military service.

Citizens.

The Citizens are divided into three guilds or classes, according to the amount of capital they possess; and have some most whimsical privileges proportioned to their rank. Those of the first rank, with a capital of from 10,000 to 50,000 roubles, may carry on home or foreign trade; may be owners of ships; may drive a carriage with two horses; and are exempt from corporal punishment. The members of the second guild, possessing a capital of from 5000 to 10,000 roubles, can only carry on home trade, but enjoy all the other rights of the first guild. The members of the third guild must enjoy a capital between 1000 and 5000 roubles; they may carry on retail trades, be proprietors of barges and boats, keep taverns, and drive one horse, though not in a coach; but are not exempt from corporal punishments. Besides these there are the foreign and designated citizens. In this class is comprehended each person who has twice served any civic office; learned men and artists who can produce

academic testimonials; bankers who possess capitals from 100,000 to 200,000 roubles; wholesale dealers, that keep no shops, and shipowners, that use the sea. These may harness two or four horses to a coach; may possess country houses and gardens; may own ships; and are exempt from bodily penalties. None of the trading classes are exempt from the military conscription; but they are allowed to procure substitutes.

Peasants.

The next class is that of the Peasants or free inhabitants of the country. In this rank are included, 1st, The ancient race of proprietors who cultivate their own lands, but do not enjoy the right of possessing slaves. The males of this description amount to about 1,150,000. 2d, The Tartars, the Bashirs, and several other races, less numerous, to the south of Siberia, who are all proprietors of the lands they cultivate. 3d, The peasants of Finland. Since the acquisition of New Finland, the privileges enjoyed by the peasants of that country, under the Swedish government, have been continued and confirmed to them; and the same rights granted to those of Old Finland, where all are now either proprietors or renters. 4th, The colonists, consisting of foreign families of agriculturists, who are proprietors of the lands they cultivate, and whose number is about 65,000. 5th, The military colonists. These are soldiers who, after having served a prescribed period, have had land given to them, and a capital sufficient to cultivate it, in the southern provinces. And lastly, The free cultivators, a new class, founded by the present Emperor in 1803. They comprehend several villages, which have been liberated as an experiment. The number of individuals in 1810 was 13,757, since which period they have rapidly increased, and are said now to be near 20,000.

Serfs.

The class next below these is that of the Serfs. They are chiefly peasants on the Crown lands, or of the province of Livonia. The first of these, the Crown peasants, amount to near 12,000,000, some of whom labour in the fields, the others in the mines and manufactories. The lot of this class seems to be placed on the confines betwixt liberty and slavery. They may rise to the rank of citizens, they may acquire property, they enjoy the protection of the laws; and, under some restrictions, may quit their residences to obtain employment for a limited time; but they are liable to be hired to the service of the mines, or to be sold. Although the Empress Catherine rarely gave these peasants away as presents to favourites, and the present Emperor has never done so, yet there is no legal security against the practice; and consequently their condition is scarcely less precarious than it was formerly. The peasants of Livonia, amounting to about 560,000, were slaves until the year 1804, when they first obtained the rights of serfs. They are now subject to some peculiar claims, but those claims are fixed, and they cannot be removed from the soil without their own consent.

Slaves.

The last and most numerous class is that of the Slaves. These amounted, in 1782, to 6,678,000 males, and at present are estimated to include 23,000,000 persons. They are in law considered as *things*, not as persons; may be bought, sold, or exchanged, with no more restrictions than are enacted in dealing for cattle; and have no other protection against their masters than what is created by a regard to their pecuniary interest. They belong to the nobles, or to such civil or military officers as have acquired the right of possessing them. They are divided into agricultural, mining, manufacturing, or domestic slaves, and have their condition only improved when drawn for military service.

Productions, Commerce, &c.

The accounts of the agricultural and manufacturing productions of Russia are fully detailed in the article of the *Encyclopædia* already mentioned. They have undergone very few alterations in their nature since that article was written; and, consequently, only that their amount has increased with the increase of population and the extension of territory, no other notice seems here to be required beyond the value of the imports and exports at different periods.

The following Table exhibits a view of the Imports into, and Exports from, the whole of the Russian dominions, by sea and by land, in bank assignation roubles, estimated at four francs each, at several periods:

Year.	Imports.	Exports.	Together.	Value in Pounds Sterling.
1797	36,980,111	54,601,368	91,581,479	15,263,570
1802	56,330,094	63,277,759	119,607,853	19,934,642
1803	55,557,675	67,148,643	122,706,318	20,451,053
1805	55,529,118	72,434,095	127,963,213	21,277,152
1819	167,599,003	210,589,310	378,188,310	66,531,235

The chief exports are corn, hemp, tallow, flax, flax-seed, iron, furs, linen goods, live cattle, timber, and potash. The principal imports are cotton and woollen goods, wines, dyers' drugs, raw silk, cotton wool, tea, sugar, coffee, salt, silk goods, fruit, and foreign silver coin.

Government.

The Government of Russia is an absolute hereditary monarchy, in which the Emperor is the sole framer of the laws; but, as in other absolute monarchies, the exercise of power is tempered and somewhat moderated by the rights and privileges to which many bodies in different provinces have, by long established usage, such claims as would be dangerous to the monarch to infringe. In the administration of the government, there is an uniformity preserved throughout all the several provinces, and in the different branches into which the executive power is divided. The Emperor, through

the directing senate, issues his ukases or laws to the Governors of the several provinces; which laws are executed by a Board, divided into sections, of which they are presidents. Besides the civil, there is a military governor in each department, to whom alone the affairs of the army are intrusted. There are deviations from this regularity of system among some tribes of Cossacks, who are ruled by their hereditary chiefs, and among the ruder classes. The ministers are appointed to different branches, denominated Foreign Affairs, War, Marine, Interior, Instruction, Finance, Justice, Police, Agriculture, and Ecclesiastical.

Law.

The Civil and Criminal codes of Russia are very imperfect, notwithstanding the efforts directed towards its improvement by the Empress Catherine, and the more practical, but unfinished attempt of the present Emperor. In the cities, two burgomasters and four counsellors; and in the country, one justice, with two noble and two plebeian proprietors, form tribunals of the first instance. From these, appeals may be made to higher courts in the several provinces; and from them again to the supreme tribunals at St Petersburg or Moscow. Among the less civilized people, great deviations from this system are still indulged; and their chiefs exercise an hereditary power in civil as well as in criminal matters, over their several tribes. A kind of Court of Conscience exists in most places, which hears verbal complaints; acts as arbiters in differences about smaller matters; and exercises power in behalf of minors and imbeciles.

Finances.

The Finances of the Russian empire are not submitted to general inspection with the same freedom, nor with the same accuracy, as is now practised by most other governments. The great depreciation experienced in the paper currency creates some difficulty in ascertaining the amount of the income, expenditure, and national debt. Besides the payments in money, so many personal services and other benefits are derived to the crown, that the bare produce of the taxes falls considerably short of the effective revenue which is extracted by the government. The chief taxes are the capitation-tax of two roubles from each peasant, and five from each burgher; the property-tax of $1\frac{3}{4}$ *per cent.* on the capital of the traders; and the duties on the importation of foreign goods. The other material sources of revenue are, the monopoly of distilled corn spirits; the profits of the coinage, of postage, and of stamped paper; and the sale of wood from the annual cuttings of the royal forests. These several branches have been estimated to have afforded, in the year 1820, about thirteen or fourteen millions Sterling, including the kingdom of Poland. The expences of the state, for many years, exceeded the income; and thus the public debt has been constantly increasing; but, it is said, the revenue now equals, or rather exceeds the expenditure. The national debt is supposed to amount to 1,000,000,000 roubles, or about L. 160,000,000 Sterling. One-half of this is believed to consist in the government paper roubles, which have been issued at a gradually increasing depreciation. The other half, or funded debt, is principally owing to foreigners, and the interest is paid to them in silver money. This state of debt, for so extensive and so numerously peopled a country, may not appear very heavy; but in Russia, there is only paper money in circulation, and the constant drain to pay the interest of the debt in the precious metals, makes the difficulty of returning to a metallic currency almost insurmountable. The project of a sinking fund was adopted in 1817, but it has hitherto made but a slight progress in redeeming the debt, or in diminishing the quantity of circulating paper; which is not at the present period worth one-fourth of its nominal value.

Army.

The increase of the Russian army has far exceeded what has been experienced in either the territory, the population, or the revenue of the empire.

Czar Peter I. in 1687 had of regular troops	10,000
Emperor Peter I. in 1724	108,350
Empress Elizabeth in 1747	162,750
Empress Catherine in 1771	198,107
——— in 1786	263,662
Emperor Paul in 1800	368,715
Emperor Alexander in 1805	428,287
——— in 1820	989,117

At the last of these periods the land force was composed of the following descriptions of troops:

	Men.
189 regiments and 565 battalions infantry	613,722
76 regiments and 563 squadrons cavalry	118,141
30 battalions artillery	47,088
Extra corps	27,632
Irregular troops (horse and foot)	105,534
Garrison troops	77,000
	989,117

Besides this prodigious force, a national guard, or militia, is organised in all parts of the empire, except in Siberia and the two northern European provinces. The expence of this vast force is very small; the articles for their equipment, provisioning, and arming, being of the cheapest and coarsest kind; and as the recruits are procured by ballot, and the pay of officers and men is low, the whole expence of the establishment is only 20,000,000 roubles, or about L. 3,000,000 Sterling. The institutions for military education are fully commensurate to the extent of the force. In the Cadets-house at Petersburg are 1000 youths; and the whole number in the empire, under appropriate instruction for the military profession, amount to nearly 3000.

Naval Force.

The navy of Russia has been neglected; and although the present force is equal to what existed in 1813, yet its character is much inferior, as many of the ships are become old. Very little timber of the best quality is to be found in the Russian territory; but every other article, required for a navy, is abundantly and cheaply supplied from domestic sources.

The fleet consists of 32 ships of the line, 18 frigates, 6 cutters, 7 brigs, 25 floating batteries, 121 gun-boats, and numerous armed small craft. This force is divided between the Baltic, the Caspian, and the Black Seas. The whole number of officers,

seamen, and marines, with which the fleet is manned, is about 32,000, who are obtained by ballot from the seafaring people of the maritime provinces. The naval ports are at Cronstadt, Revel, Sweaborg, and Rotschensalm, on the Baltic; at Archangel, on the White Sea; at Nikolajew, Sewastopel, Taganrog, and Cherson, on the Black Sea; and at Astrachan, on the Caspian.

Having thus given a view of the general condition and circumstances of the Russian empire, in those respects in which alterations have taken place since the article in the *Encyclopædia* was written; we may now proceed to a more particular description of its members and divisions.

European Russia, including the Dependent Kingdom of Poland.

The grand division of European Russia is into six provinces, viz.

Names.	Extent in Square Miles.	Population.
East Sea Province	192,064	3,857,107
Great Russia	938,929	21,330,279
Little Russia	88,256	6,124,585
South or New Russia	192,362	2,550,700
West Russia	139,712	8,480,022
Poland	46,741	2,732,324

It thus appears, that in the whole of European Russia, the density of the population is somewhat less than $2\frac{1}{4}$ persons to each square mile, or nearly one person to 282 English statute acres.

The East Sea province is divided into the following governments, viz.

Names.	Extent in Square Miles.	Population.
Petersburg	18,090	808,512
Finland	134,444	1,346,139
Esthonia	6,890	396,032
Livonia	20,110	737,734
Courland	9,544	568,690

The inhabitants in this province are nearly one to twenty acres of land. The principal cities in the government of Petersburg are, Petersburg, one of the capitals of the empire, with 300,000 inhabitants; Kronstadt, with 35,000; Narva, with 3800. In Finland are Helsingfors, with 8000 inhabitants; Abo, with 11,300; Uleaborg, with 3350; and Wiborg, with 3200. The chief city of Esthonia is Revel, with 15,000 inhabitants. The cities of Livonia are Riga, with 30,000; Dorpat, with 6000; and Pernau, with 2500. The only city of note, in Courland, is Miltau, containing 12,000 inhabitants. No other places than those here noticed, in the East Sea province, contain so many as 2000 inhabitants.

The province of Great Russia is divided into 19 governments, whose names, extent, and population, are as follows:

Names.	Extent in Square Miles.	Population.
Moscow	10,500	1,289,823
Smolensko	22,088	1,297,055
Pskow, or Pleskow	22,293	783,945
Novogorod	54,997	960,000
Olonez	80,789	352,904
Archangel	346,133	162,666
Wologda	163,712	802,178
Kostroma	38,570	1,422,700
Nishegorod	20,501	1,349,508
Wolodimir	18,669	1,306,046
Tula	11,904	1,093,721
Kaluga	12,736	1,159,600
Twer	24,213	1,233,358
Jaroslaw	14,528	1,022,991
Kurst	14,954	1,611,109
Orel	16,779	1,270,085
Riäsan	14,553	1,270,291
Tambow	22,869	1,391,400
Woronesh	32,487	1,436,357

The inhabitants in this province are nearly one to twenty-four acres of land. The chief cities in the government of Moscow are, first, Moscow, one of the capitals of the empire, nearly the whole of which was destroyed by the fire in 1812, when the French troops were in possession of it. It has been since rebuilt in a great part, as far as regards the dwellings of individuals, but many of the public edifices are yet unfinished. There are now rebuilt upwards of 200 churches, more than 9000 houses, and between 6000 and 7000 booths. The number of inhabitants in the summer of 1820 was about 200,000; and in the following winter, when the nobles, with their numerous establishments of domestics and slaves, took up their residence in the city, they are said to have been increased to about 50,000. The city of Kolomna contains 5809 inhabitants, Serpuchow 5540, Wereja 5941, and Moshaish 3944; all the others have less than 3000 inhabitants. In the government of Smolensko, the city of that name contains about 12,000 persons, Weasma 1150. Pleskow contains 10,000, and Toropez 12,000 inhabitants. Novogorod has 10,000, and Storaja Russa 5250 persons. In the government of Olonez the city of Petrosawodsh has 3285, and Kargapol 3032. The only city in the government of Archangel is of that name, and contains 8000 souls. The population of the city of Wologda amounts to 10,529, and of Oustjug to 12,000. Kostroma contains 8000, Galitzkaja 3300, and Galitsch 6000 inhabitants. Nishegorod has 12,000, and Arsamas 8000 persons. No place in the government of Wolodimir contains 2000 persons; the capital of the same name has only 1500. Tula or Toola, the chief city of the government of that name, has 30,000 inhabitants, Bjeleu 7000, and Obajew 3200. The city of Kaluga contains 25,000 souls, Borowsk 6000, and Koselsk 3500. In the government of Twer, the city of that name contains about 20,000 people, Stariza 3500, Ostaschkow 6207, Torshok 15,000, Wolotschok 3500, Kalasin 3521, Kashin 3513, and Beshezk 3120. In Jaroslaw, the city of the name has a po-

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pulation of 24,000, Uglitsch 7000, and Rostow 6000. The government of Kurst contains the city of that name, with 20,000 inhabitants, Rylsk with 6000, Sudsha with 7000, Bielgorod with 8000, Korotsha with 4000, and Obojan with 5500. The city of Orel has 20,000 inhabitants, Minsk 6000, Bolchow 14,000, Briansk 5000, Trubtochwsk 3500, Siawsk 5,000 Liwny 6000, and Jelez 8000. The city of Riasan, in the government of that name, contains 5000 souls, Soraisk 4500, and Kasimow 10,000. The government of Tombow contains Tombow, with 15,000 souls, Hoslow with 8000, Lebedjan with 3500, Lipesk with 6400, Kirsanow with 4500, Morshansk with 5500, Shazh with 6500, Temnikow with 4500, and Jelatma with 5800. Woronesh has no city of more than 3000 souls, except the capital of the same name, which contains about 15,000.

The province of Little Russia, composed chiefly of the Ukraine, or the country of the Cossacks, the best peopled of the whole empire, is now divided into four governments, viz.

Names.	Extent in Square Miles.	Population.
Kiew	17,557	1,353,800
Slobodsk Ukraine	21,717	1,471,000
Tschernigow	22,983	1,378,500
Pultowa	16,810	1,933,000

The inhabitants are about one to eight acres of land. The city of Kiew, or Kiow, contains about 40,000 inhabitants; the population of no other place in the government reaches beyond 3000. Charkow contains 15,000, Sumy 15,000, Bielopolje 9000, Lebidjan 8970, Achtyrka 12,788, Bogoduchow 6749, Walkj 9286, Smijew 5000, and Isjum 4248 inhabitants. The smaller towns in Slobodsk Ukraine are numerous. In the government of Tschernigow, the city of that name contains 10,000, Neskin 16,000, Gluchow 9000, Nowgorod 8000, Starodub 4000, and Mglin 5077 inhabitants. Pultowa has 10,000, Mirgorod 7437, Lubni 6000, Pereaslawl 6000, Solotonscha 5500, and Krementschuk 8000 inhabitants; besides which, the smaller towns and villages in the government of Pultowa are well peopled.

The province of South Russia, a great part of which has been added to the empire in the course of the eighteenth, and the first ten years of the nineteenth century, is divided into five governments, viz.

Names.	Extent in Square Miles.	Population.
Catherinoslaw	29,757	944,994
Cherson	25,728	523,600
Taurida	43,562	437,428
Bessarabia	18,711	310,000
Land of the Don Cossacks	77,034	398,103

The inhabitants are about one to forty-nine acres of land. The city of Catherinoslaw contains about 5000 inhabitants; none of the other places more than 2000; and only two reach to that number. The towns in the government of Cherson are almost wholly of very recent foundation. The capital of that name contains 5000 inhabitants, Nicolajew (founded in 1789) 9000, and Jelisawetgrad 12,000. The greater part of the inhabitants of Taurida are of the Tartar race, and of the Mahomedan religion. The population of the cities has been very fluctuating since this district first came under the Russian government. Kaffa or Feodosia, formerly the seat of the Genoese trade, with the countries around the Black Sea, and then stated to have had a population of 40,000, when visited by Dr Clarke, had only 50 families; but in 1820 had increased to more than 4000 persons. Simferopol, a frontier garrison city, has 20,000 inhabitants, of various nations and religions. Baktschisarai contains 5777 persons, mostly Tartars, and Koslow 4410 of the sane description. Bessarabia was formerly a part of Moldavia. Akerman, a strongly fortified place, has a population of about 10,000. Ismail, celebrated for its siege, and once containing 40,000 people, is still in ruins, and nearly without inhabitants. The only city among the Don Cossacks is Ischerkask, in a very unhealthy situation, but containing a population of 15,000.

European Russia.

West Russia comprehends those provinces of Poland and Lithuania which have been formed into a component part of the Russian empire. They have been divided into eight governments, viz.

Names.	Extent in Square Miles.	Population.
Wilna	23,061	1,328,100
Grodno	11,434	842,500
Minsh	14,140	914,686
Witebesk	23,424	1,135,100
Mohileu	19,584	963,400
Wolhynia	29,739	1,464,000
Podolia	20,224	1,606,400
Bialystock	3,370	219,050

The inhabitants are about one to eleven acres of land. The chief cities and their population are, in Wilna, Wilna with 25,000, of whom 12,000 are Jews, and Kieydani, with 5000 inhabitants. In Grodno, the city of that name, with 5000, and Slonem 6000. In Minsh 6000, in Slusk and in Pinsk 4000. In Witebesk, the city of that name, 15,000, Welisk 4700, Dunaburg 4000, and Polozk 3200. The city of Mohileu has 16,000. The cities of Wolhynia are Berdyczeu with 10,000, Zaslow with 4500, Staro Constantino with 4200, Ostrog with 4500, Rowno with 3270, Waldimer with 3126, and Dubno with 5635 inhabitants. In Podolia are the cities of Kamenetz, with 5650 inhabitants, and Mohileu with 7000. The city of Bialystock contains 3350 inhabitants; and no other place of that government 2000.

Kingdom of Poland.

The ancient kingdom of Poland has, by successive divisions, been reduced to a small territory, when compared with its former extent. A description of the Duchy of Posen, a part of it, is to be found in this work, under the head of PRUSSIA. Gallicia is united to Austria; part is included in the present province of West Russia; and a very small portion, con-

European Russia.

taining the city of Cracow, and the surrounding district, is formed into an independent republic. The part now called the kingdom of Poland is, properly speaking, a Russian viceroyalty. It has, indeed, been permitted to retain some of its ancient forms and institutions; but it is effectively, at present, a mere province of the Russian empire, and in that view we must now consider it.

The grand divisions are into eight Waywodeships, and these are again subdivided into Obwodeships.

Name of Waywodeship.	Extent in Square Miles.	Population in 1819.	Capitals and their Inhabitants.	
Massovia ...	6858	481,000	Warsaw	98,000
Kalitch......	6862	512,000	Kalitch	7,310
Cracow	4500	445,000	Kielce	5,000
Sandomir...	5982	432,000	Radom	1,500
Lublin	6657	490,000	Lublin	10,300
Polachia	4864	286,000	Siedlec	2,145
Augustow	6870	335,000	Suwalki	3,000
Plock	6635	364,000	Plock	6,000

The inhabitants are one to about nine acres of land.

Soil, Climate, and Productions.

Poland is generally a level country, but towards the south is more undulating, and some of the hills rise to the height of 2000 feet above the level of the sea. It is well supplied with running streams. To the north of the Vistula and the Bug, the soil is for the most part sandy, but generally fertile. In the south, the soil is a rich vegetable mould, intermixed with marshes and morasses. The climate is colder in the winter than in the same latitude in Germany and France. The productions are, corn of all kinds, hemp, flax, hops, tobacco, wood, fruit, cattle, abundance of game, river fish, honey, and wax. The minerals are copper, lead, iron, and calamine. There is much marble, alabaster, and limestone; and in some parts salt, sulphur, saltpetre, and coal. The manufacturing labour is chiefly destined to provide clothing, and the most homely articles for domestic use. The Jews are the chief traders, manufacturers, and innkeepers; and their dwellings, in the towns and villages, are far better than those of the clergy, or even the lower nobility.

Different Classes of Inhabitants.

The inhabitants have increased at an extraordinary rate since the return of tranquillity. The difference between the year 1815 and 1819 appears to be 708,400 individuals, many of whom are German colonists. The number of Jews in 1819 was 212,944. All religious professions enjoy equal rights. The Roman Catholic is the predominant sect; their hierarchy consists of an archbishop and five bishops. There is a Unitarian bishop of the Greek ritual, who presides over 200 churches. The Lutherans are about 150,000, who have a consistory and superintendent. The Calvinists are about 6000. Besides these are several smaller Christian sects, and more than 100 families of Mahomedans. The nobility are very numerous, comprehending more than 60,000 families. They are distinguished by different titles, but have none of the privileges of rank, unless they possess property. Many of them are very poor, but about 100 enjoy very extensive estates. Some restrictions in the use of titles have been recently introduced, which prevent those from assuming them who do not possess a graduated specific amount of income according to the title. Professors of the universities of ten years standing, civil and military officers of the same length of service, and such burghers as make useful discoveries, may be now admitted into the ranks of nobility. The burghers have some civil rights granted in addition to those formerly enjoyed. The peasants have, however, been most benefited by the divisions that have been made of Poland. Under the ancient system, this numerous class of persons had neither property nor rights; and their common proverb, "We have nothing but what we drink," is sufficiently descriptive of their low condition, and their habitual intemperance. They have now acquired personal freedom, and the right of holding landed property. To this extension of freedom may, in some measure, be attributed the recent increase of inhabitants; as many of the German emigrants would not have availed themselves of the greater fertility of the Polish soil, whilst the old slavish degradation of the peasants was continued.

Constitution of Government.

The present constitution of Poland is a limited monarchy. The Emperor nominates the King, who has the sole executive power. The legislature is divided into two chambers. The upper, or senate, consists of thirty members, nominated for life by the king; of whom ten are bishops, or clergy (approved by the Pope), ten are Waywodes, and the other ten Castellans, or Magnates. The lower house consists of sixty members, who must have attained 40 years. They are chosen for nine years, but every third year the retirement of one-third of them is determined by lot. They are elected by the provincial assemblies of the nobles, where there are at least 600 qualified electors. A commissioner is appointed for civil affairs, another for criminal matters, and a third for finances. These three persons, with the ministers who sit in the assembly, not by election, but of right, are the only members permitted to speak, and all the others give their votes in silence. The assemblies are convened every other year, and sit only fourteen days to dispatch such business as is laid before them. They have no power to initiate a law, nor the right to exercise any inquisitorial functions. The assent of the upper chamber is not indispensable for promulgating a new law, if it be approved by the lower chamber, on the recommendation of the king.

Law.

The Poles had formerly few or no written laws; but in the year 1257, Boleslau the Fifth introduced the use of the law-book of Magdeburg, which has been continued ever since as the compendium of civil and criminal law. The local courts consist of the landowners; the next higher court extends over each Waywodeship, and from them there is a court of general appeal. A new code of laws has been drawn up, but is not yet in practice.

Finances.

The income of Poland is about L.850,000 Sterling, derived from a hearth and capitation-tax; from stamps, customs, lotteries, and posting. The civil list is about L.170,000; one-half of which arises from the

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national domains, the other is taken from the public treasury. The debts of the state, including old and new, amount to 200,000 Polish gulden. The expences are not accurately known, as no budget has yet been made public since the introduction of the new constitution, and the accession of the Russian Imperial family.

Army.

The army consists of 30,000 infantry and 20,000 cavalry, of whom the royal guards form a body of 12,000; but the military organization is not yet completed. Every Pole, without exception of rank or religion, is, by the law, a soldier from the age of twenty to thirty; but, in practice, numerous exceptions to the general rule are allowed. The muskets are supplied from a manufactory at Kouskie, but the cannon, as well as cloths for uniforms, must be drawn from other countries. There is a scarcity of gunpowder, although saltpetre is abundant. *

Asiatic Russia.

The dominion of Russia comprehends the whole of Northern Asia, and extends from longitude 37° 14′ to 190° 22′ east from London; and from latitude 38° 58′ to 78° 2′ north. This vast dominion is calculated to be spread over $\frac{27}{50}$ths of the land of the globe, and to be rather more than one-third of the surface of the whole of the continental portions of it.

Face of the Country.

The eastern division of the Asiatic Russian territory, from the river Jenisy, or Yenesii, has, on its southern and eastern parts, vast mountain ranges; and on its interior there are several chains that run to the Arctic Ocean in vast masses. It is covered with woods, large lakes, or extensive elevated plains, and terminates, towards the shores of the Frozen Ocean, in vast fields of eternal ice. The division to the westward has, indeed, some ranges of mountains, especially the Altaian chain on the south, the Ural range on the west, and the ridge of Caucasus on the south-west, with their various projecting branches; but taken as a whole, it may be described as a vast level plain, partially watered, but by its climate and soil, ill adapted for the increase or the comfort of human beings. The soil to the westward of the Ural mountains is generally very fertile, and produces abundant returns of corn, but to the eastward it is barren, cold, and scarcely exhibits any symptoms of vegetation.

Steppes.

Although Russia in Asia is in part surrounded by, and in some parts covered with mountains, yet there are several barren plains of great extent, usually denominated *Steppes*. The most remarkable of these are, the Kirgissch Steppe, between the Irtish and the Orenburg boundary line. It is a very dry and barren district, with some lakes, whose water is saline. The few rivers have copious streams in the spring from the melted snows, but in summer become dried up. The Wolgau Kalmuck Steppe, between the Ural and the Wolga, extending from the Caspian Sea to Samara, is of the same description. The Kuman Steppe, extending from the Caspian Sea to the Don and the Wolga, resembles a lake recently dried up; being formed of a mixture of sand and clay with an undulating surface, intermixed with salt lakes, and utterly destitute of vegetation. The other steppes, with slight varieties of character, are that of Terek, between the rivers Terek and Kuma, touching on the Caspian Sea; of Kuban, extending from Kuban to the Manitsch and the lake of Bolschei; of Jettish to the eastward of the Ural; of Ischim on both sides the river of that name, between Tobol and the Irtish; and the Baraba, between the Irtish and the Ob. To these may be added the Arctic plain, between the 67th degree of latitude and the Frozen Ocean, whose whole surface is little more than morasses, mixed with rocks, and bound up by frost betwixt ten and eleven months in the year. These extensive plains are sometimes passed by the wandering tribes, who find subsistence on the less sterile spots which are to be met with on the banks of the rivers that bound them.

Rivers.

The rivers of Asiatic Russia that empty themselves into the Arctic Sea, are among the most considerable of the ancient world. The most remarkable of these are, 1*st*, The Ob, whose course is 2800 miles in length, during which it receives the great rivers, the Tom, the Kek, the Irtish (which, before the junction, runs 2500 miles, and takes into its stream the waters of the Ischim, the Tobal, and many other rivers), the Tyda, and all their tributary streams. 2*d*, The Yenesii, or Jenisy, which has a course of 2000 miles, with fewer sinuosities than are usually observed in other great rivers. It receives the waters of fourteen large streams and all their tributary collections. 3*d*, The Piasana, whose course is 300 miles. 4*th*, The Taimurskoe, a short stream issuing from a lake of the same name, in latitude 70°. 5*th*, The Khatanga, which empties itself into the bay of Khatangaskoi, on the Frozen Ocean. 6*th*, The Anabara, an Arctic stream. 7*th*, The Olenk, whose waters only become considerable after entering the Arctic circle. 8*th*, The Lena, one of the largest of the Asiatic Russian rivers. It rises in the Backal mountains to the north of China, in latitude 52° 30′, and empties itself into the ocean in latitude 70° 40′, and longitude 164° 26′, after receiving the waters of fourteen large rivers and their numerous tributary streams. 9*th*, The Omoloi. 10*th*, The Jana. 11*th*, The Indigirka. 12*th*, The Alazeja. 13*th*, Kolyma. 14*th*, The Tchauna; and, 15*th*, The Amgonia. The streams whose courses have been traced to fall into the sea of Kamtschatka, between Asia and America, are the Anadyr, the Katirka, the Kamtschatka, the Penshena, the Tilcha, the Ischiga, the Tauna, the Okhota, the Uda, the Argun, and the Shilka. The Black Sea receives from Russian Asia the great rivers Kooban and Rioni, with their tributary waters, and several smaller streams which arise on the western sides of the mountains of Caucasus. The rivers which discharge themselves into the Caspian Sea are, 1*st*, The Wolga, which comes

* The best recent works on Poland are, *Guide du Voyageur en Pologne*, Varsovie, 1820; *Polen Staats veranderungen und Letztere Verwaltung*, von F. Jäkel, Wien, 1819.

Asiatic Russia.

out of the centre of European Russia, and forms the principal means of internal water communication between the European and Asiatic portions of the empire. Its course is upwards of 2500 miles in length, during the progress of which it receives the streams of fourteen large, and of a vast number of smaller rivers. 2*d*, The Kuma, rising in the northern Caucasus. 3*d*, The Teret, a mountain torrent, nearly dry in summer. 4*th*, The Akhracan. 5*th*, The Sulach, both rivers only abundant in the spring, and nearly dry in summer. 6*th*, The Kur, a stream formed by a union of several others in Armenia and Georgia, and navigable from Teflis. 7*th*, The Ural, rising in the Uralian range of mountains, and forming a course of nearly 1400 miles, during which it receives the waters of six large, and numerous smaller rivers. 8*th*, The Jemba, a river coming from the north, and running about 450 miles.

Lakes.

The lakes in Russian Asia are very numerous, and some of them very extensive. One of the largest is the Baikil in Siberia, between latitude 52° and 55°, and longitude 104° 26′, and 109° 56′, extending over 11,180 square miles. Its water is clear and bright, the depth varies from 18 to 480 feet. It is covered with ice from the middle of December till April. The river Angara, which runs to the Jenisy, issues from it. It receives the waters of several streams which come either from the Chinese territory or its vicinity. The lakes next in extent are the Tchani and the Piasenskoc, both in the government of Tomsk. Almost every province has one or more lakes, several of which are of salt water, on whose banks a natural crystallization prepares culinary salt for the use of the inhabitants.

Agricultural Products.

The agriculture necessarily varies both in its practices and its productions in countries so extensive as those we are sketching. By an harvest table before us, it appears that the winter corn (wheat and rye) does not yield, on an average, more than three and a half for one grain that is sowed; and the summer corn (barley and oats) not much more than two and a half for one. The increase of production seems to be about as progressive as the increase of population. By a return of the whole produce of the harvest of 1808, it appears that the whole quantity raised was 43,424,966 tschetwerts on 29,854,622 quarters; from which, if two-sevenths be allowed for seed, there will remain for subsistence 21,324,760 quarters. Taking the whole population at 10,164,000, and allowing for 1,164,000 who eat no bread, there will have been about 18 bushels of corn for each individual. In many parts the goats and sheep, and in some the oxen, furnish food for the inhabitants; whilst aid for the subsistence of others is afforded from the fish of the seas, lakes, and rivers.

The mines of Russian Asia are by far more productive than those of any other portion of the empire; as from them is extracted the whole of the gold, silver, and lead, nine-tenths of the copper, and eleven-twelfths of the iron which is brought into use. By the latest returns the whole produce was as follows:

Gold,	17,940	ounces.
Silver,	540,000	ounces.
Copper,	3,360	tons.*
Lead,	900	tons.
Bar-iron,	1,680,000	tons.
Vitriol,	5,184	tons.
Rock Salt,	14,675	quintals.

According to the work from which these statements are taken,† the culinary salt, annually prepared in Asiatic Russia, is 830,000 quintals.

Fisheries, &c.

The fishery is a considerable branch of industry, and furnishes articles for exportation. The crown lets to farm its fishing on the Caspian Sea to some companies in Astrachan. The produce consists chiefly of the flesh and the roe of the sturgeon, and of the skins of seals. In 1815 there were employed 1847 boats, and 6688 men in this fishing. The Wolga and some other rivers yield prodigious quantities of excellent fish. The whole value of this object is estimated at 8,000,000 silver roubles, or more than L. 1,500,000 Sterling. The chase is a business of much importance, both on account of the food which it supplies for subsistence, of the peltry which furnishes for winter garments, as well as articles for an export trade. The productions of the forests not only supply the article of fuel which the severe climate requires, but furnish large quantities both for building and firing to other nations. Most of the forests belong to the crown: those of Asia, exclusive of Siberia, are calculated to cover 43,500,000 desjatincs, or nearly 100,000,000 English statute acres.

Manufactures and Commerce.

The manufactures are very few, and very homely. The best article produced is the leather. Some linen is made of a coarse kind. In Casan and Astrachan there are establishments for making cotton, woollen, and silk goods, and for various kinds of hardware and glass. The breweries, but especially the distilleries, are more numerous than any other manufacturing objects. Making corn spirits is a royal monopoly, but in some of the Asiatic cities it is let to farm by the government. The chief commerce is internal between the several provinces whose productions are most different from each other. There is an increasing transit trade between China, India, and Europe, and custom-houses are established on the frontiers, at which the tolls are collected. We have no statements of the extent of this trade that are sufficiently accurate to create much confidence. The value of the goods, which in 1809 were manifested in the governments of Irtusk and Kiachta, on the Chinese

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* It appears from a recent intelligent work (Tooke *On High and Low Prices*, Part II.), that the exportation of copper from Russia, which before 1818 was trifling, in that year amounted to 155 tons; in 1819 1419; in 1820 4466; in 1821 5023; and in 1822 3545 tons.

† *Die Wichtigkeit des Russichen Bergbaus*, von Herman.

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frontier, was 5,049,138 silver roubles, or about L. 840,000 Sterling, including both exports and imports.

Divisions.

The names and divisions, both military and political, of Russian Asia, are at present the following:

Kingdom of Casan.

	Governments.	Extent.	Population.	Capitals.
Kingdom of Casan.	Casan	22,272	1,138,804	Casan.
	Wiatka	47,381	1,265,900	Wiatka.
	Perm	127,017	1,232,474	Perm.
	Simbirsk	29,910	1,095,145	Simbirsk.
	Pensa.........	16,597	1,044,824	Pensa.

The city of Casan, about five miles from the Wolga, in north latitude 55° 47′ 51″, and east longitude 49° 26′ 41″, is an increasing place, with 25,000 inhabitants. In it the governor and Archbishop have palaces, and there are some few other good stone buildings. A very wide-spreading conflagration destroyed many hundred houses in 1815, and the new buildings since erected on their site have much improved the appearance of the city, which is now half European and half Asiatic. The city of Wiätka, in latitude 58° 24′, and longitude 50° 48′, contains 12,000 inhabitants, employed in the trades of corn, tallow, and hemp, and in the manufacture of leather, soap, and some hardware. Most of its productions are conveyed by the Dwina to Archangel. Stobosk, in latitude 58° 30′, and longitude 50° 20′, has 6000 inhabitants, occupied as those of Wiätka. Perm, in latitude 58° 1′ 13″, erected into a city in 1780, is built almost wholly of wood, and contains 6000 inhabitants, employed chiefly in trade arising from the copper mines. Soltikumsk, in latitude 59° 39′, and longitude 56° 50′, supports about 6000 people, chiefly by copper, tin, and gold manufactures. Irbit, in latitude 57° 35′, and longitude 63° 26′, contains 3600 inhabitants, who depend mainly on the great fairs which are held there, in which the productions of Europe and Asia are exchanged for each other. The sales in the fair have amounted to 6,287,000 roubles; of which 800,000 consisted of cloth, 1,400,000 of Chinese goods, 850,000 of peltry, 9000 of spices, 350,000 of sugar, and 350,000 of linen. Jekaterinburg, in latitude 56° 50′ 15″, and longitude 60° 56′, contains 6000 inhabitants, who subsist on trades dependant on the mines, and arising also from its being on the high road to Siberia. Simbirsk, in latitude 54° 24′, and longitude 49° 55″, contains 15,000 persons, who find subsistence from several manufactures, from the fishery, and carrying trades on the Wolga, and from the corn, tallow, and hemp of the surrounding districts. Samara, in latitude 53° 53′, and longitude 49° 57′, contains 3500 inhabitants, who are employed in the fishery on the Wolga, and export by it large quantities of fresh and salted fish, and of caviare, or the roes of the sturgeon. The city of Pensa, in latitude 53° 30′, and longitude 45° 44′, contains 1697 private dwellings, of which only three are built of stone, and 10,000 inhabitants. There is a cathedral, five stone, and eight wooden churches, and several other public buildings. Its principal trade consists in leather, linen, soap, and corn; part of which is conveyed to the different markets by land carriage, and part is sent by the small river Sura to the Wolga. Saransk, in latitude 54° 23′, and longitude 44° 41′, contains 6200 inhabitants.

Kingdom of Astrachan.

	Governments.	Extent in Square Miles.	Population.	Capitals.
Kingdom of Astrachan.	Saratow	91,563	1,305,170	Saratow.
	Astrachan	83,178	200,000	Astrachan.
	Caucasus ...	33,813	130,000	Georgiewsk.
	Orenburg	120,021	1,044,000	Orenburg.

The city of Saratow, in latitude 51° 31′ 28″, and longitude 46° 6′, contains 6500 inhabitants, whose chief dependence is on the produce of the fisheries on the Wolga, and the transit commerce between Eastern and Western Russia, carried on by means of that river. Molsk, in latitude 52° 4′, and longitude 47° 37′, on the right bank of the Wolga, has 5000 inhabitants; and trades on the river. Kusnezk, in latitude 53° 7′, and longitude 46° 42′, has about 5000 inhabitants. Astrachan, in latitude 46° 21′ 12″, and longitude 48° 8′ 17″, is situated at the spot where the Wolga begins to form that delta by which, in various branches, it enters the Caspian Sea. It contains several public edifices for government, and for the various religious forms of worship which its Christian, Mahomedan, and Hindoo inhabitants follow. There is a naval arsenal, a seminary for Greek priests, several inferior seminaries for the different classes of the people, and an imperial botanic garden. The inhabitants are about 30,000, who manufacture silks, cottons, leather, soap, linen, and some other articles. The fisheries are considerable, and in 1815 employed 1847 vessels, with 6688 men. The gardens and vineyards are important objects, and produce much fruit, and tolerable wine and vinegar; which are conveyed by the Wolga to the interior of European Russia. Georgiewsk, or St George's, a fortified city, in latitude 44° 4′, and longitude 42° 47′, contains about 3000 inhabitants, some few of whom are citizens or merchants, but the greater part are Cossacks. Mosdok on the Terek, in latitude 43° 43′ 46″, and longitude 27° 52′ 51″, contains 4000 people, who trade by that river with the Caspian Sea. Kislan Cower, on the same river, in latitude 43° 51′ 15″, and longitude 46° 20′, is a rapidly rising place, chiefly from the industry of the Armenians, with 10,000 inhabitants. The city of Orenburg is situated on the river Ural, in latitude 51° 46′ 5″, and longitude 55° 10′ 17″, and is the head quarters of the military power, and the seat of the provincial government; it is fortified, the streets paved, and has a good market-place in its centre. It contained in 1820 about 2900 houses, and rather more than 20,000 inhabitants. There are manufactures of cloth, linen, soap, and leather. The chief support of the population is derived from commerce. About half a mile from the city stands the exchange, a large mass of square building, containing 392 shops, in which the productions of Europe and Asia

Asiatic Russia.

are exchanged. The building has two gates, by one of which the Europeans enter, and by the other the Asiatics. The sales effected in this place amount to upwards of 1,000,000 roubles annually. The country round it is a complete waste. Ufa, in latitude 54° 42′ 45″, and longitude 55° 59′ 17″, has a population of 6000 inhabitants, of whom one-half are Tartars, who carry on considerable trade, and are employed in agriculture and breeding cattle. Troizk, in latitude 54° 10′, and longitude 55° 10′ 17″, is, next to Orenburg, the most considerable trading place, and has like it an exchange, in which are 300 shops.

Kingdom of Siberia.

	Government.	Extent in Square Miles.	Population.	Capitals.
Kingdom of Siberia.	Tobolsk ...	532,501	887,186	Tobolsk
	Tomsk	1,289,056	500,000	Tomsk
	Irkwzk	2,655,660	575,000	Irkwzk

In this statement of the population, the numbers of the wandering tribes, who are very numerous, and some very small, is necessarily an estimate, and not the result of that census which has been taken of the settled inhabitants. The extent of land is thus near 1900 acres to each individual of the population. Each of the governments is divided into circles, in which the capital is denominated a city, though the number of its inhabitants, in many cases, scarcely equal those of the villages in more civilized countries.

The city of Tobolsk, in latitude 58° 12′ 30″, and longitude 68° 31′, was founded, in 1587, at the junction of the rivers Tobolsk and Irtish ; and contained, in 1820, 25,000 inhabitants, who are employed in the trade for domestic consumption, as well as in the transit trade between China and Europe. Since a great fire in 1784, which destroyed most of the houses, then built of wood, the buildings have been constructed of stone, and on much better plans than formerly. Tomsk, in latitude 56° 29′ 39″, and longitude 85° 36′ 23″, is situated on the navigable river of the same name, at its junction with the Uschaika, on the great road to China. It has few manufactures, but depends principally on transit trade, and on some great fairs, where much business is transacted. Kainsk, in latitude 55° 33′, and longitude 78° 40′, has 3500 inhabitants, and is the place of a great annual fair. Barnaul, in latitude 53° 20′, and longitude 83° 32′ 32″, has 6000 inhabitants, who chiefly derive their subsistence from the mines in the surrounding district. Korjakow, on the Irtish, has 3500 inhabitants, chiefly employed in mining. Kusnezk contains 3400, and Krasnoijarsk 3500 inhabitants, employed in mining, and in the transit trade with China. Irkuzk is the seat of the governor of the province, in latitude 52° 16′ 41″, and longitude 104° 39′ 17″. It contains 30,000 inhabitants, many of whom are Tartars or Chinese, and others, in their dress and manners, approach nearly to those people. It is the chief seat of the trade with China, and for that of furs, which are brought from the north-east coasts of Asia, and the north-west shores of America. Okhozk, in latitude 59° 20′ 10″, and longitude 143° 18′ 17″, is the easternmost city of the Russian dominion. It is the chief seat of the American Company, and there are many vessels built here for their trade. The inhabitants are between 2000 and 3000, mostly military men, agents of the company, or ship carpenters. The fishery is productive ; but the attempts to grow corn have been hitherto unsuccessful. The other places, though many of them are denominated cities, are of small population. In the circle of Kamschatka, one of the divisions of the government of Irkurzk, there are two places denominated cities, Mishnii and Werchnoi ; the former only with 300, and the latter with 200 inhabitants.

Islands in the Polar and Eastern Oceans.

In the Polar Ocean are the groups of New Siberia and of the Bear's Island. The first consists of four large and many smaller islands. They are covered with snow the greater part of the year ; their surface is generally rocky, and on some of them are marks of volcanoes. They are chiefly remarkable for the bones and teeth of the mammoth, rhinoceros, buffalo, and other animals, which are found upon and beneath the surface of the ground. The search for this ivory first induced the Russians to visit these islands ; and an expedition for exploring them was equipped in 1820, which had not returned when the last dispatches to the government were forwarded. These islands do not appear to be inhabited, though marks of human beings have been discovered by the Russians engaged in the fisheries. The Bear's Island group consists of six small islands, with several kinds of plants and shrubs on them, but no trees ; although their shores are found to be covered with large drift wood. The southernmost point of these islands is in latitude 69° 5′, and they extend to latitude 76° 20′. Their longitude is between 154° and 183° 50′ east.

In the Eastern Ocean the islands are thus classed :

1st, The islands of Gevosbewy and Nelken, in Behring's Straits, in latitude 65° 4′, with about 400 people.

2d, St Lawrence, latitude 63° 40′, and longitude 190° 26′, and three smaller islands on the south-east of it.

3d, St Mathew's, in latitude 60°, in the sea of Kamtschatka, consisting of three islands, one of which was named by some early British navigators Pinnacle Island.

4th, The Prebelow Islands, in latitude 57°. Two of them have been named St Paul and St George. The former is about 28 miles long, and 20 broad, and both are well stocked with animals whose furs are valuable.

5th, The Aleutian Islands. This is a chain of islands extending from the peninsula of Kamtschatka to the American peninsula of Alaschka, between 51° and 55° 10′ north latitude, and 167° and 197° east longitude. (See ALEUTIAN ISLANDS in this *Supplement.*)

6th, The Kurile Islands. This chain extends from north latitude 43° 48′ to 50° 56′, and from longitude 145° 5′ to 156° 30′ east. They are evidently of vol-

canic origin. In some of them good water is found, but others are utterly destitute of it. The few inhabitants are of Japanese origin. Many of these islands have hitherto obtained no European names; but nineteen of the most considerable have been named by the Russians.

Provinces of Caucasus.

	Government.	Extent in Square Miles.	Population.	Capitals.
Provinces of Caucasus.	Grusia	26,645	600,000	Teflis.
	Awchasa	5,077	56,000	Anakria.
	Tscherkessia	32,547	800,000	Waldikawkas.
	Daghestan ...	9,249	184,000	Derbent.
	Schirwan	9,493	120,000	Baku.

Thus it appears there is one human being to 645 acres of land.

Grusia is recently so denominated by the Russians from the river of that name, but is better known by the Asiatic name Curdistan, or the European name Georgia. It is subdivided into the provinces of Imeretus, Mingrelia, and Guria, and further divided into circles, or districts. The greater part of these provinces were wrested from Persia in the war which terminated in 1813; or the authority over the native princes was acquired at different periods. From having been long the seat of bloody and wasting hostilities, the country has become almost depopulated; but, under a settled government, such as it has now acquired, as much of the land is fertile, it has rapidly increased in population and cultivation, and many of the wandering tribes are gradually becoming stationary. The city of Teflis, in latitude 41° 28′ 30″, and longitude 44° 23′, is the capital, containing 18,000 inhabitants, besides the Russian garrison. It is a place of considerable commerce with Turkey, and with Persia, and by the navigable river Kur, is connected with the Caspian Sea. Anakaria, though called a city by the Russians, is rather a military post than a civil or trading place. Waldikawkus is also a military station, considered as the key to the Caucasian provinces, and rapidly increasing. Derbent, in latitude 42° 5′ 45″, and longitude 47° 45′, on the Caspian Sea, contains a population of 4000 persons, mostly Mahomedans, who are employed in manufactures of cotton, silk, carpets, and leather. The vineyards around the city produce excellent wine. Taxki, the capital of one of the ancient princes, or khans, in latitude 42° 59′, and longitude 46° 58′, contains 10,000 inhabitants, employed in making silk goods, and in agriculture. Baku is a Russian fortress of the first class. In it is the palace built by Shah Abbas. The harbour is the best on the Caspian Sea, from which wheat, maize, wine, silk, opium, salt, saltpetre, and naphtha, are exported.

American Russia.

The claim of Russia to that dominion on the west coast of North America, which is now to be discussed by different powers, is founded on the right of prior discovery. In 1648, as the Russians assert, a person named Deschneew sailed from the river Kalyma, and passed round Cape Shelatskoi to Kamtschatka. His account of this voyage was generally discredited in Europe, and scarcely engaged any attention in Russia itself; where no measures were taken to verify the narration till the year 1725, when Behrings was equipped for northern discovery, and, in 1728, succeeded in passing through the straits separating Asia from America, which have since borne his name. In that and the following year, with Tschirikoff and Spangberg, he reached the latitude 67° 18′, and next year explored the Kurile Islands. In 1730 and 1731, Gwosdew and Krupischew made the land of America, in latitude 66°, and Behrings himself that part which lies in latitude 58° 28′. Captain Cook, in 1778, explored the whole of this coast, as high as latitude 70° 44′; and has since been followed by the other English navigators Clarke, Vancouver, Dixon, Portlock, and Meares; by the Frenchman Peyrouse, and by the Russian Billings. These several officers have given names to the different capes, inlets, and rivers. The Russian government was desirous to appropriate to itself the beneficial trade in furs which this extensive district furnished. With this view the American Company was formed in 1799. It soon established its chief factory on the island Kodjah, and founded several smaller dependant branches along the American shore from latitude 55°, and even to Badoga, in latitude 38° 50′, in the vicinity of the Spanish settlements. It does not appear, by any accounts that have reached us, how far the government of Russia laid claim to the exclusive right of trading with those countries till the year 1822; when an Ukase was issued, asserting a right, not only to the whole coast from latitude 51° northwards, but to the seas which border them, to the extent of 100 leagues from the shores. Notice to this effect has been formally given to the British and United States' ships; and the trade hitherto carried on by them has been prohibited. The British claim the whole coast from latitude 51° to 56° 30′; whilst the Americans have some pretensions to portions of it.

Without entering farther into the different views which may be entertained by the several claimants to the dominion of the countries, designated by us as New Albion, New Hanover, New Cornwall, and New Norfolk, we shall consider the territory of Russia as extending from 56° 30′ to 71° north; and from the point of Alaska to Mackenzie's River from west to east; thus extending over 14° 30′ of latitude, and 27° 40′ of longitude. Unless we knew the trending of the land between Mackenzie's River and Behring's Straits, which will be ascertained if Captain Parry should succeed in the object of his present voyage, any estimate of its extent can only be an approximation to the truth. The medium calculation would make it extend over 512,000 square miles. The several Russian factories on this coast contain from 800 to 1000 people on the whole, who traffic with the Aborigines for peltry, and direct such of them as have been reduced to obedience, and a kind of civilization, as to the spots which they shall select for hunting. The furs collected here are nearly of the same description as are furnished from Hudson's

American Russia ‖ Rutlandshire.

Bay. The capital of the company, that conducts the whole Russian operations in America, amounts to 2,747,000 roubles; each share receives a dividend of 156 roubles; and the present value of their actions is 3700 roubles. The Emperor, as protector of the company, receives one-tenth of all the furs for his share. The factories of the company are in general only an assemblage of huts, defended by palisades, and just sufficiently strong to protect the property from any attacks that the tribes of Indians can make. The country, even close to them, remains in a state of nature, except at the southernmost of them, Bodago, in latitude 38° 20′, where, under the guns of the fort, about 100 huts are erected, inhabited by Russians and natives, who cultivate corn, potatoes, turnips, and hemp.

The recent voyage of the Russian Captain Kotzebue has thrown much light on the geography of the north-west coast of America, and we hope for still greater information from the present expedition under Captain Parry.

(Besides the works already referred to in this article, see *Russland oder das Russ. Reich u. s. w.*, von K. Mor von Brömsen. Berlin, 1819. *Dörstellung der Russ. Monarchie nach ihren wichtigsten Politischen Beziehungen*, von B. von Wickmann. Leipzig, 1814. *Vollstandiges Handbuch der neuesten Erdebeschreibung*, von Gaspari, Hassel, Cannabich, und Gutsmuths. Weimar, 1821. Clarke's *Travels in Various Countries of Europe, Asia, and Africa.* Klaproth's *Reise durch Russland und Siberia nach Mongolischen Tartarei.* Tübingen, 1815. Engelhardt und Parrot, *Reise durch die Krim und den Kaukasus.* Berlin, 1815. Ehrmanns und Lindners *Neueste Kunde, von Asien.* Weimar, 1812. *Guide du Voyageur en Pologne.* Varsovie, 1820. *Tableau de la Pologne, ancienne et moderne*, par Malte-Brun. Paris, 1807.) (W. W.)

Boundaries, extent, and divisions.

RUTLANDSHIRE, an English county, nearly in the centre of the kingdom, and the smallest of all the divisions so denominated. It is bounded by Lincolnshire on the east and north-east, by Leicestershire on the north-west and west, and by Northamptonshire on the south. Its length, from north to south, is sixteen, and its breadth, from east to west, is twelve miles. The square contents are 200 miles, or 128,000 acres. It is divided into five hundreds, and contains two market towns, Uppingham and Okeham, and 49 parishes; being a greater number, in proportion to its extent, than any other county in the kingdom.

Political state.

It gives only one title at present, that of Duke, to the family of Manners; two former peerages, that of Ferrars of Oakham, and Noel of Exton, being extinct. Only two members are returned to the House of Commons from the county, and none from either of the towns. In judicial affairs, it is on the midland circuit of the judges; and in ecclesiastical matters it has formed, since the year 1541, a portion of the bishoprick of Peterborough.

Face of the country.

The appearance of this small county is pleasing to the traveller. It is much diversified by ranges of moderate hills, running from east to west, in some parts well timbered. Between these ranges of hills the valleys, of about half a mile in breadth, are luxuriant and verdant. The principal vale, called Catmose, is in the centre of the county, having to the north a tract of table land, overlooking the well wooded plains of Leicester, Lincoln, and Nottinghamshire. The eastern part is more diversified; the southern division of it consisting of a beautiful valley, stretching towards Northamptonshire, and the western, bordering on Leicestershire, being abundantly wooded.

Soil and climate.

The soil on the east and south-east parts is chiefly shallow, resting upon a basis of limestone, composed of clays and loams. The other parts consist principally of a tenacious but fertile loam; but the vale of Catmose enjoys a most fertile soil of good clay, or red loam, or a grateful mixture of both those earths. A peculiarity of the soil is a redness which generally prevails, and which tinges all the waters of the country.

Mr Parkinson, surveyor for the Board of Agriculture, estimates the land of the county in the following manner, viz.

Pasture land	34,861 acres.
Arable land	42,536
Wastes	30
Woods	2,815
Meadows	9,356
Commons	693
Plantations	65
Lakes and ponds	44

The woods of this county were far more extensive in former ages than they are at present. The ancient forest of Leafield, and the chase of Beaumont, though now under the plough, once occupied a great portion of the surface. The climate is generally accounted peculiarly soft and healthy; and the elevation is of that medium kind which equally exempts it from the pernicious effects of moist exhalations and cold mountain fogs.

Agriculture.

The agriculture, though it has partaken of some modern improvements, is not conducted, upon the whole, in the best manner. In some parts, the reprobated system of two corn crops succeeding a fallow is still continued. In other parts, after a fallow, barley is sown with clover; the clover is mowed two years, or sometimes fed the second year, and then, after one ploughing, the land is sown with wheat. In some cases, on the lighter lands, the four course system of turnips, barley, clover, and wheat, is followed. The wheat of Rutlandshire is highly valued for seed, and much in request in even very distant counties. Nearly two-thirds of the land are tithe free, and in all the late inclosures, provisions to that end have been inserted in the acts of Parliament for effecting them. The cows of Rutlandshire are remarkable for the richness of their milk, though they yield but a small quantity. The rich cheese, commonly known as Stilton, is chiefly

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made in the dairies of this county. As many oxen are brought from the more northern countries, and fattened in Rutlandshire, as are bred within it: the annual number of each is from 2700 to 3000. The sheep are more numerous in proportion than horned cattle. Mr Parkinson calculated them to be about 80,000; consisting of old and new Leicesters, of Southdowns, and a few Lincolnshires. It has been remarked, that though the quality of the wool has increased in fineness, the diminution in the weight of the fleeces has of late years more than counterbalanced that advantage.

Rivers and Canal.

The small rivulets that water this district run into the two rivers, the Guash, or Wash, which passes through it, or the Walland, which forms its southern boundary. The latter river is navigable only to Stamford, on the confines of Rutlandshire; but is useful in opening a communication with the ocean. A canal has been constructed from Oakham to Melton Mowbray, by which a supply of coals has been drawn from the mines of Leicestershire.

Population.

Rutlandshire is neither a manufacturing nor a mineral district, but depends exclusively on its agriculture. By the returns in 1801, the inhabitants were 16,356; viz. 7978 males, and 8378 females; in 1811 the numbers were 16,380, viz. 7931 males, and 8449 females; in 1821 they were 18,487, viz. 9223 males, and 9264 females.

The residences of noblemen and gentlemen in this county hold nearly the same proportion as in the other divisions of England; the most remarkable are, Ayston, G. B. Breidnell, Esq.; Burley on the Hill, Earl of Winchelsea; Cotsmore House, Earl of Lonsdale; Exton, Colonel Noel; Lyndon, Thomas Barker, Esq.; Normanton, Sir Gilbert Heathcote; Ryall, Matthew Pierrepoint, Esq.

See Parkinson's *Agricultural Survey*; and *Beauties of England and Wales.* (W. W.)

S A L

Extent and Boundaries.

SALOP, or SHROPSHIRE, an inland county of England. It is bounded on the north by Cheshire, and the Welsh counties of Flint and Denbigh; on the west by the Welsh counties of Denbigh, Montgomery, and Radnor; on the south by Herefordshire and Worcestershire; and on the east by Staffordshire. It is of an oblong figure, extending from north to south, and contains a variety of projections and indentations. Its greatest length is about 46, and its greatest breadth 37 miles. Its superficial contents are 1341 square miles, or 854,240 statute acres.

Civil and Ecclesiastical Divisions.

This county is divided into fifteen districts, or hundreds, of which five are on the north-east side of the river Severn, three extend to both banks of that river, and the remainder are on its south-west side. The ecclesiastical divisions of the county are into the diocese of Lichfield and Coventry, extending over 114 churches,—of Hereford over 127,—of Worcester over 3,—and of St Asaph over 12;—besides which there are 6 in the peculiar jurisdiction of Bridgenorth, making in the whole 262 churches, of which 229 are parochial.

Population.

The population of this county has increased at a much less ratio, between the census of 1811 and that of 1821, than that of any other of the English or Welsh counties; the average increase of the kingdom being 16 *per cent.* and that of Shropshire only 5 *per cent.* By the latter enumeration, the number of individuals was 206,153; of whom 102,056 were males, and 104,097 females. The number of *families* were 41,636; of whom 18,414 were chiefly employed in agriculture, 17,485 in trade, manufactures, or handicraft, and 5737 were not comprised in either of those classes. The number of houses were 38,663 inhabited, 179 building, and 1012 uninhabited.

Face of the Country.

The face of the country is much diversified. On the western side it has the wild appearance of the adjoining principality of Wales. Throughout the rest of the county the land is rather undulating, tolerably wooded, and with many beautiful rivulets meandering along the different valleys. The whole tract of country, from Wellington to the termination of the county between Oswestry and Chirk, exhibits the mild beauties of a fertile and cultivated district, inclosed by well formed hedges into fields, of dimensions well calculated for advantageous husbandry; and ornamented with several domains of noblemen and gentlemen, which present a most pleasing succession of pictures to the traveller.

That singular insulated mountain, the Wrekin, rising from a plain to the height of 1100 feet, exhibits its sugar-loaf form over the tops of the smaller elevations in its vicinity, and increases the interest of the scenery. In the southern division of the county, the Brown Clee Hill, and the Titterson Clee Hill, rise to greater elevations than the Wrekin, and produce much picturesque variety.

Soil and Climate.

In a county of such extent, the soil must be very varied. On the eastern side, the valleys are flat and warm, and the soil generally of a sandy nature. In the middle part, the soil is more tenacious, and the bottoms of the wider valleys have frequently a stiff but rich clay. On the most western parts, the soil is very shallow, resting upon rocks of varied descriptions; and is better calculated for sheep pasture than for producing grain. There are some moor lands, but inclosures and drainage have considerably diminished their extent. A very great portion of the soil rests on a limestone subsoil; and almost the whole of the plains are easy to work with light ploughs, and two or three horses. The easterly winds generally prevail in the spring, and the westerly in autumn; the former are more remarkable for their regularity than the latter. The whole of the county enjoys a salubrious air; but on the hills, on the western side, the cold of winter is most intensely felt.

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Rivers, Lakes, Canals, and Railroads.

The chief river is the Severn, which runs through the whole extent of the county from north-west to south-east. It is navigable at all seasons to the Bristol Channel downwards, and in wet seasons upwards to Welshpool, in Montgomeryshire. The navigation is, however, at all times, impeded by many obstructions. In dry weather, the fords are only passable with difficulty, and in very wet weather the floods cover the banks, and extend so far over the level land on both sides, that the barges cannot be drawn up, from wanting a path on which the men who draw them can securely walk. It is one of the singularities of this navigation, that men are employed instead of horses, as on other rivers, to draw the vessels against the stream. Imperfect as this navigation is, it is, however, the chief source of the wealth of the country, as affording the means of conveying to good markets the various heavy productions which it yields. The fish found in the Severn, in its course through Shropshire, are salmon, pike, flounders, grayling, and eels. There are also some lampreys in the Shropshire part of the Severn, but they are less abundant than in the lower parts of the river. The principal tributary rivers are the Camlet, the Vyrnwey, the Tern, the Clun, the Ony, and the Teme. There are, besides, innumerable rivulets and streams, which adorn and fertilize the country. The lakes of Shropshire, though neither numerous nor extensive, form a variety in its landscapes rarely to be seen in the midland counties of England. Adjoining the town of Ellesmere is a beautiful lake of 116 acres, with some others smaller near it. On the western side of the county is Marton Pool, of 45 acres. On the north of the Severn are Fennymere, Llynclyspool, and Ancot; and at Shrawardine is a fine lake of 40 acres. That side of the county which most abounds in running streams has few or no lakes. The canals of this county, if not equal in extent to those in some others, yield to none in their construction, or the obstacles they have surmounted, or in the beneficial consequences by which they have been followed. The first canal was a private undertaking by a Mr Reynolds, completed in 1788, for the conveyance of his iron-stone and coals. It was a short canal, but a descent of seventy-three feet was conducted by a well contrived inclined plane, and double railroad, by means of which the loaded boat passing down drew up another with a load, nearly equal to one-third of its own weight. This contrivance was found to be applicable to similar purposes, upon a larger scale, and was speedily adopted by a company who, under the power of an act of Parliament, soon constructed the Shropshire Canal, which passes through the most considerable iron and coal works, till it reaches the Severn. The Ellesmere Canal is a most important undertaking, as by it a communication is opened between the Severn and all the great canals and rivers in the north of England. Bristol and Liverpool are thus become connected by inland navigation, and the rivers Severn, Dee, Mersey, Trent, and Humber, are united for the purposes of conveyance. In districts where the inequalities of the surface would not admit of canals, iron railways have been constructed, on which heavy goods are conveyed, in appropriate waggons, with a great saving in the expence of carriage.

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Agriculture.

There are few counties in which the agricultural business is, on the whole, better conducted than Shropshire. The land is very well adapted for the turnip cultivation, and the large flocks of sheep which are commonly fed on that valuable root a great part of the year, supply abundance of manure for the due cultivation of the different kinds of grain. The most prevailing breed of sheep are the Southdown, but many of the New Leicesters are to be seen, and in the hilly parts of the county are many of the fine-woolled Welsh sheep. The meadows on the banks of the Severn, and on the flat lands contiguous to the smaller streams, afford pasturage for numerous cows, whose milk, when converted into cheese, is commonly sold under the denomination of Cheshire. The corn generally cultivated is either wheat, barley, oats, or pease, and the crops, on an average, equal in productiveness those of the best districts of the kingdom. Hops are grown in small quantities on that part of the county which adjoins to Herefordshire. Some small portions of land are appropriated to the growth of hemp and flax. The cultivation of potatoes has been very much extended of late years, and now furnishes a large proportion of the aliment of the labouring part of the population. The growth of hay, and the cultivation of artificial grasses, are more neglected than any other branch of rural economy. On the flat lands, the deposits from the overflowing of the streams sufficiently enriches them without any artificial manure; but from the embankments being neglected, the hay produced on such situations is liable to be much injured by the floods that frequently occur in summer.

Minerals

A great portion of the wealth of this county consists in the mineral productions, which are most profusely found beneath its surface. The chief of these are lead, iron, limestone, freestone, pipe-clay, and coals. The lead is procured in considerable quantities chiefly from the mines of the Hope and Snailbeach. The matrix of the ore is crystallized quartz, sulphate and carbonate of barytes, and carbonate of lime. The iron ore is found contiguous to the coal, and frequently close to it. This is especially the case about Colebrook Dale, a division peculiarly rich in those minerals. This district is about eight miles long and two broad, on the banks of the Severn, on the western side of the Wrekin, and running parallel with it, from north-east to south-west. The whole, but especially the southern part of the coal district, is considerably above the plain of Shropshire, so that at one part the height is 500 feet above the Severn. The works of the Dale supply both ore and coal, as well as limestone, in great quantities; and every part of the process, from digging the ore to the completion of the manufacture, including the conversion of the coal into coke, is performed on the spot. Arthur Young, describing this part of the county, says, "Colebrook Dale is a winding glen, between two immense hills, which break into various forms, being all thickly covered, and forming most beautiful sheets of hanging woods. The noise of the forges, mills, furnaces, &c., with all their vast machinery; the flames bursting from the furnaces, with the burning coal, and the smoke of the limekilns, are altogether horribly

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sublime." A bridge of cast iron, the first, we believe, constructed in this kingdom, thrown over the Severn, gives to the whole scenery a most romantic appearance. Soon after it was ascertained that iron might be made with coals, reduced to the state of coke, as well as from wood, the operation of coking was begun here by Lord Dundonald, with a view to obtain the fossil tar in the course of the process. This operation led to the discovery of that gas, extracted from coal, whose brilliant light now serves to illuminate so many of our streets and public buildings. In this dale was discovered, in opening a coal mine, a copious spring of fossil tar. It yielded, at first, very plenteously, but the quantity diminished in a few years, and though it still runs, its produce is but of small amount. Though the iron-works in this dale were the first begun, on a large scale, they are by no means confined to it; for in many other parts of the county, they are carried on to an extent that is unequalled in any other country but Great Britain.

Manufactures and Trade.

Besides the process of separating the iron from its ore, and bringing it into the state of bar-iron and pig-iron, the other steps in the application of that mineral to general purposes are made within this county. The larger kind of iron goods, whether cast or wrought, are prepared, and most of the iron bridges which have been erected in different parts of the kingdom have been formed here into such a state as only to require to be put together in the places where they were destined to be ultimately fixed. Some of the largest establishments for making porcelain have been formed here, especially that for iron-stone china in Colebrook Dale, which has lowered the price of that beautiful commodity so as to bring it within the reach of a greater number of consumers than could formerly afford it. Manufactures of a coarser kind of earthenware, and of tobacco-pipes, are carried on at Broseley and other places. The raw materials of which these articles are formed are almost all found near the spots where they are converted to those useful and profitable purposes. The manufacture of cotton has been recently introduced into this county, and establishments formed at Coleham and some other places, which rival the largest factories in the county of Lancaster. Many branches of the linen trade have been long, though not extensively, carried on in the northern part of the county. Some of the coarser kinds of woollens are made in different districts; but none of the establishments for their fabrication are upon an extensive scale. The trade in Welsh flannels centres in a great degree in Shrewsbury. The merchants of that town repair to the markets of Welshpool and Oswestry, and make their purchases of the small country weavers, who bring their goods in an unfinished state; and the pieces are rendered fit for the markets to which they are destined by the Shrewsbury traders. A coarser kind of woollens, called Welsh webs, are prepared in the same manner, and are exported to the West Indies for clothing the negroes.

Shrewsbury.

Shrewsbury, the county town of Shropshire, from its vicinity to Wales, in which the towns are few, and from its distance from any other large town, has ever been considered as a kind of provincial capital. It is situated on a circular peninsula, of considerable elevation, formed by the curvatures of the Severn. It presents, at every approach, a pleasing variety of views; and the noble sweep of the river, which seems to embrace it, heightens at every turn the charm of the scenery. The exterior ranges of houses command the rich and beautiful landscapes of the surrounding country. The stately spires of two venerable churches, and the massive towers of the castle, give that imposing grandeur to the whole which is commonly felt in contemplating the works of antiquity. The walks between the river and the town are finely shaded by an avenue of lofty trees, and furnish an agreeable promenàde to the inhabitants. The interior of the town by no means corresponds with its external beauty. The streets are intricately dispersed, many of them steep and narrow, and all badly paved. They exhibit a strange contrast of ancient and modern buildings, and are as uncouth in their names as in their appearance. This town, as well as many other parts of the county, exhibits now many interesting remains of antiquity. Among these is the castle, placed on the narrow neck of land, by which the only entrance to the town can be gained without passing a bridge. The remains consist of the keep, a square building of 100 feet, connected with two towers; the walls of the inner court; and the great arch of the interior gate. The keep is the most perfect of the whole mass of building. The walls of this building are ten feet in thickness, and its beams of very large dimensions. It is stated to have been built by Roger de Montgomery, the Norman, as a feudal hold; but being forfeited to the crown in the reign of Henry I., was used as a royal fortress in subsequent periods, to check the incursions of the less civilized Welsh. The remains of the abbey, erected by the same founder as the castle, rewards the lover of antiquities for the inspection of them. The most perfect of the remains of this edifice is an octagonal structure six feet in diameter, usually called the Stone Pulpit, standing upon a portion of the ruined wall. It is crowned by an obtuse dome of stone-work at about eight feet from the base, supported on six narrow pointed arches rising on pillars. The ancient Church of St Chad, which fell down in 1788, presents an interesting group of ruins. That of St Mary, founded by Edgar, as well as St Alkmunds, founded by Queen Elfleda, daughter of Offa, King of Mercia, have received such alterations in more recent periods, that they exhibit the architectural taste of several successive ages. The charitable institutions of Shrewsbury, consisting of hospitals, infirmary, schools, and other establishments, rather exceed the proportion to be found in other places of equal population, and do much credit to the liberality of the natives.

Antiquities.

Our limits do not admit of lengthened descriptions of the numerous remains of ancient architecture which are still existing in this county. The most remarkable are Haugmond Abbey, about four miles from Shrewsbury; the walls of Wroxeter, of British and Roman construction; the Abbey of Buildwas, founded in 1135 by Roger, Bishop of Chester, for monks of the Cistercian order;

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the Monastery of Wenlock, founded in 680, destroyed by the Danes, and afterwards re-established; the Roman Camp called the Walls at Quatford; the Castle of Ludlow, celebrated for its splendour in the reigns of Henry VIII. and of Elizabeth;—during the latter period the residence of the Sidneys, and in the reign of Charles I. immortalized as the place where Milton composed some of his works; Wannington Castle, near Oswestry, a house of strength before the Norman Conquest; Lilleshall Abbey, near Newport, with one of the most highly adorned Norman arches in the kingdom; and Boscobel House, with the oak in the grounds near it which served as a shelter to Charles II. when, after the battle of Worcester, he was closely pursued by the victorious party.

Representation.

Shropshire returns to Parliament two members for the county, and two each for the boroughs of Shrewsbury, Ludlow, Wenlock, Bridgenorth, and Bishop's Castle.

Titles and Seats.

The titles of peers derived from the county are —Earl of Shrewsbury, and Barons Hill and Forrester. As there are fewer titles derived from this county, so the seats of peers are much fewer than in any other of the same extent. The most remarkable residences of noblemen and gentlemen are the following: Walcot Hall, Earl Powis; Hardwicke, Lord Hill; Ross Hall and Willey Park, Lord Forrester; Apley Park, Thomas Whitmore, M. P.; Dudmaston, William Whitmore, M. P.; Pitchford, Honourable C. C. C. Jenkinson, M. P.; Hodnett, Reginald Heber, M. P.; Hawkstone, Sir Richard Hill, Bart. M. P.; Kinlet Hall, W. C. Childe, Esq. M. P.; Stanley Hall, Sir T. Tyrwhit Jones, Bart.; Altingham, Lord Berwick; Manor House, Sir G. Jerningham, Bart.; Pradoe, Honourable Thomas Kenyon; Pentrepant Hall, Honourable F. West; Orlaton Hall, William Cludde, Esq.; Downton Castle, Richard Payne Knight, Esq.; Oakley Park, Honourable Robert Clive; Plowden Hall, Edward Plowden, Esq.; Audlim, Lady Cotton.

By the census of 1821, the population of the towns was as follows: Shrewsbury, 21,695; Wenlock, 17,265; Wellington, 8390; Hales Owen, 8187; Ellesmere, 6056; Bridgenorth, 4345; Ludlow, 4820; Oswestry, 3910; Newport, 2343; Bishop's Castle, 1880.

See Plymley's *Survey of Shropshire;* Aikin's *Tour;* Telford's *Account of the Inland Navigation of Shropshire; Antiquities of Shrewsbury*, by the Rev. Hugh Owen; and *Beauties of England and Wales.* (w. w.)

Origin and History of the Kingdom.

SAXONY. The kingdom of Saxony has been formed out of the principality of the same name. The duchy from which the sovereign dignity arose was no part of the ancient duchy, but a Vandal province, which Albert, Margrave of Saltzweded, seized and transmitted as an inheritance to his son Bernard. This Bernard received the ducal rank from the Emperor Frederick, usually distinguished by the name of Rothbar, or Redbeard; and his territories were spread out from the Weser to the Rhine, and from Westphalia to the borders of Bohemia. In these turbulent times power was necessary to preserve the dominion possessed by the petty sovereigns; and divisions arising between different branches of the family, the other Saxon duchies were formed into independent states, leaving to the descendants of Bernard the sovereignty over the Margravate of Meissen, and that of Saxony in a contracted state; whilst the houses of Gotha, of Weimar, of Coburg, and some others, inherited the whole of the western parts, which Albert had seized. Meissen and the remaining part of Saxony was then formed into one independent state, on which the electoral dignity was conferred by the Emperor Charles V. because of the adverse conduct of the Elector of the house of Weimar, the oldest branch of the family, in the wars which arose from the reformation of Luther.

Saxony.

From that period till the war of the French Revolution, though its territories had been occupied, and its capital taken by Frederick of Prussia, Saxony had experienced but little alteration. When France attacked Prussia in 1806, the Elector of Saxony took part with the latter power, but the reverse occasioned by the battle of Jena compelled him to join the conqueror. An alliance was formed between Buonaparte and the Elector, who, as the Empire of Germany was dissolved, and the electoral dignity annihilated, assumed, under the sanction of the Ruler of France, the rank and title of King. The newly created King maintained with good faith the alliance, which necessity had compelled him to form, till the overthrow of the French armies, in the decisive battle of Leipsic, occasioned in part by the defection of his troops; on which event he was taken prisoner by the allied sovereigns in that city, and his dominions placed under sequestration. When, at length, he was reinstated on his throne, nearly one-half of his subjects were forced to transfer their allegiance to the Prussian monarch, to whose kingdom was added the duchy of Saxony itself, comprising the most fertile part of his dominions.

Extent, Boundaries, and Population.

The kingdom of Saxony, in its present state, is a compact and connected territory. It extends from 28° 5′ to 31° 13′ east longitude, and from 50° 10′ to 51° 31′ north latitude. It is bounded on the north and north-east by Prussia; on the south-east and south by Austria; on the south-west by Bavaria; on the west by the principality of Reus and the duchy of Saxe Gotha, and on the north-west by Prussia. Its square extent is about 7150 miles, or 4,625,000 English acres.

It is divided into five circles or provinces, and these are subdivided into Amts or Baliwichs.

Circles or Provinces.	Number of Inhabitants.	Extent in English Acres.	Capitals.
Meissen ...	297,945	1,006,080	Dresden & Meissen.
Leipsic	216,355	743,080	Leipsic.
Erzgebirge	459,264	1,403,520	Freiburg.
Voightland	88,639	440,320	Planen.
Lusatia ...	169,879	1,031,680	Bautzen.
	1,232,082	4,624,680	

Saxony.

The inhabitants are divided into those who live

In two large cities, - - -	85,167
In six cities, between 5000 and 15,000 souls,	51,319
In thirty-four cities, between 2500 and 5000,	112,660
In ninety-three towns, between 1000 and 2500, - - -	130,428
In towns of less than 1000, and in villages,	852,508
	1,232,082

This state of the population is drawn from a census taken in 1817.

Face of the Country.

The northern part of the kingdom of Saxony is, for the most part, a level, or an undulating country; but on the south it is very mountainous. The mountains rise in three successive ridges, denominated the Vorgeberg, Mithelgeberg, and Hochgeberge; the southernmost of these, bordering on Bohemia, is the loftiest. The highest points of these mountains are those of the Fichtelberg, 3730 feet; Auersberg, 2931 feet; the Lausche, 2400 feet; and Hochwald, 2299 feet.

Saxon Switzerland.

A part of this mountainous district, betwixt Dresden and Bohemia, usually denominated Saxon Switzerland, has peculiar charms for the lovers of picturesque scenery. It is about 28 miles in length, and 23 in breadth, displaying deep chasms bordered by perpendicular rocks, some naked, and others clothed with every variety of trees. Rapid streams pour from declivities, forming cascades in some parts, and in others, in deep vales, meander through verdant meadows, without their issue or their egress being discoverable by the observer from the precipices which enclose such recesses, and from whence he can see no path by which the vales can be reached. Through this mass of mountains the river Elbe has worn itself a passage, by a most tortuous course, and washes the bases of rocks, in some parts of near one thousand feet perpendicular height, from whose summit that stream appears to the beholder as an insignificant rivulet. From the surface of this mountain plain rise the pinnacles of rocks, on which castles, in the feudal times, were erected, some of whose ruins add to the romantic grandeur of the prospect; whilst others, such as Koenigstein and Litherstein, have had applied to them all the arts of modern fortification, and are the most impregnable fortresses in the Saxon dominions. Koenigstein especially, though, from its great height, it appears to terminate in a point, has on its apex strong walls, surrounding buildings in which the treasures of the crown are secured in times of danger, with ground to yield potatoes enough to feed the garrison, as that vegetable grows there to perfection; though, from being 1400 feet high, the rigid cold of winter is most severely felt. This fortress, and that of Lillienstein on the opposite side of the Elbe, are considered to be the keys to Bohemia. Few spots in Europe create greater interest in the geologist, the botanist, or the lover of picturesque scenery, than this portion of the country so appropriately denominated Saxon Switzerland.

Rivers.

The principal river of Saxony, and that to which almost all the others contribute their streams, though not till it has left this kingdom, is the Elbe. It enters from Bohemia, and is navigable for barges through the whole of its Saxon course. The other rivers are the Black Elster, which rises in Lusatia, and soon enters the Prussian territory; the Spree, which comes out of Bohemia, divides itself into two branches near Bautzen, and then passes into Prussia. These rivers fall into the Elbe on its right bank. On the left bank it receives the Moldau, which has two sources in Bohemia, and in Saxony unites with the Zwichau, and runs parallel to the Elbe till it joins that stream at Dessau. The White Elster rises in Voightland, with many curvatures, reaches the suburbs of the city of Leipsic, and, receiving there the small river Pleisse, falls into the Saale, and ultimately is lost in the Elbe, above Magdeburg. The only river that does not run to the Elbe is the Neisse, which rises in the eastern corner of the kingdom, and, passing into Silesia, at length is emptied into the Oder. There are no lakes in Saxony, nor any canals, except such as are used in the mining districts for conveying the ore to the mills.

Agriculture.

As compared with most parts of Germany, the agriculture of Saxony is much advanced. Wherever the soil is capable of cultivation, it is worked with diligence; and the more hilly and poorer soils have a good herbage, and yield pasture to numerous flocks and herds. The sides of the mountains towards the Elbe, from Pirna to Meissen, are covered with vines which yield both red and white wine; the former from the vicinity of Pilnitz and Loschwitz, and the latter from Hoflasnitz, are the most valued; but the great portion of the Saxon wine is of a very indifferent quality. The best of them are produced from the vineyards belonging to the king; and though they are sold at the highest prices, it is very doubtful if the expences of cultivation, and the rent which might be obtained for the land, does not exceed what is produced by the sale of the wine.

The whole of Saxony is highly productive of fruit, and the care and skill exercised in its cultivation is amply rewarded. Great destruction to the fruit trees took place during the tremendous military conflicts of which the country was the theatre; but still the orchards and gardens are very extensive, and new trees, planted since the wasting warfare of 1813, are beginning to yield their products. The calamities which were injurious to the fruit trees have lessened the number of cattle of every description; in the year 1817, in many districts of the circle of Meissen, not a single head of cattle was to be found. The bee-hives were destroyed by the same events; and it will yet require some years before Saxony can, as in past periods, supply the neighbouring countries with meat, hides, honey, and wax. The sheep were better preserved than the other kinds of animals, being mostly driven to the mountainous districts. These have increased, and great attention having been paid to breeding them so as to produce the finest wools, they have succeeded to such an extent, that their fleeces are now superior to those of Spain, and furnish the chief agricultural article which is exported.

The arable land is chiefly cultivated on a three course system, consisting of a fallow, winter sown grain, and spring sown grain. In some cases there is a fallow crop of flax, hemp, or potatoes. The

winter corn that succeeds is generally rye, and sometimes, though less extensively, wheat; the summer corn which follows is chiefly oats and sometimes barley. The greater part of the arable land is in common fields, held under a feudal tenure, over which the lord of the manor has the right of depasturing his flocks between the harvest and the next seed time. The farming occupations are generally very small, and the increase of grain through the whole kingdom is said not to average more than five for one. The culture of potatoes has been very much extended of late years, and forms almost exclusively the food of the labouring classes in the mountainous districts. Tobacco, hemp, flax, wood, hops, and chiccory, are grown in some parts of the kingdom, but neither of them to the extent which the consumption of the country requires. The woods of the kingdom, since the separation of its best portions, are insufficient to furnish the inhabitants with the necessary fuel; and though abundance of coal is found near Dresden, it is of so sulphureous a nature as to be deemed unwholesome, and is used only by those who are unable to pay the high price for wood which its scarcity has created.

Minerals.

Saxony abounds in minerals, and though the veins, in general, are far from being of great thickness, the ore is tolerably rich; which, added to superior skill and economy in working the mines, and separating the metals, makes them very beneficial to the crown, to whom the greater portion of them belong. The mineralogical school of Freyberg has had a wonderful influence, not only in Saxony, but in all parts of the world, in increasing the knowledge and improving the practice of the operative labourers in the mining art. The annual produce of the silver mines is about 400,000 ounces; besides this, they yield copper, lead, tin, iron, sulphur, quicksilver, bismuth, arsenic, and coal. Gold is found in very small quantities.

Manufactures.

In no part of the continent has manufacturing industry been carried to so great an extent, or occupied so large a proportion of the population, as in Saxony. Before the separation from it of the most productive agricultural provinces, it was calculated that two-fifths of the inhabitants were employed in manufactures; but since that unfortunate event, it is estimated that three-fifths are occupied in commerce and manufactures, and only two-fifths in agriculture. It is only by the extent of its manufactures that the country can be furnished with the means of paying for those articles of the first necessity, of which a sufficiency is not now produced within it. The provinces which supplied corn, fuel, and salt, have been ceded to Prussia, and those articles must be paid for by the sales of the minerals and manufactures. During the continuance of Buonaparte's continental system, the Saxon manufacturers enjoyed a most extensive trade, and the encouragement thus obtained gave an impulse which directed the efforts and the capital of the country towards their perfection; but the division of labour was not carried to such an extent, nor was the application of machinery so generally adopted, as to enable them to withstand the competition with the British goods, which peace introduced into many of those markets which they had before almost exclusively supplied. It would include almost the whole catalogue of European manufactures to enumerate all the respective kinds of goods made in Saxony. Woollens, linens, cottons, and silks for clothing; iron, brass, and copper wares; paper, leather, earthenware, hats, musical instruments, and turnery-ware; various chemical and dyeing preparations; clocks, watches, swords, guns, and pistols, are all comprehended in the list of Saxon manufactures.

Commerce.

The commerce of a country, whose inhabitants are chiefly occupied in manufactures, and produce an insufficiency of food for their own consumption, must be extensive. The trade of Saxony chiefly centres in the city of Leipsic, from whence, at the time of the two annual fairs, the greater part of the manufactures are disposed of, and contracts are made for such foreign commodities as the supply of the country demands. As the fairs of Frankfort on the Maine precede, and those of Frankfort on the Oder follow, the fairs of Leipsic, some portion of the trade is carried on by those channels. The roads leading to Leipsic are generally good, and trains of waggons, loaded with goods, are to be seen proceeding to and from that place at all times; many of which come from Flanders, Holland, Hamburg, and Brunswick, on one side, and from Russia, Poland, and even Turkey, on the other. At the fairs of Leipsic, the new books printed in most parts of Germany are brought for publication. There the publishers meet and exchange the works of one part of the country, where the German language is spoken, with those of another. So extensive is this trade, that it is said the commissions on it to the brokers and merchants of Leipsic amount to more than 40,000 rix-dollars a year. The whole sales at the fairs in that city are estimated, including exports and imports, at about 20,000,000 rix-dollars, or more than L. 3,000,000 Sterling. Saxony disposes, in this way, of sheep's wool, fine woollen goods, linen and thread lace, yarn and worsted, ironmongery, cutlery and braziery, and books. It receives in return, corn, wine, salt, wood, and colonial wares. Although the river Elbe is navigable from the ocean to the interior of Saxony, it is only used for the conveyance of the heaviest goods, and for them but partially. It is found that the tolls on that river, with the risk of damage and of robbery, make it more advantageous to convey commodities by land than by water.

Government.

The government is a monarchy hereditary in the Saxon Albertine line, and in failure of that, on the Ernestine, or Saxe Weimar branch of the family. The monarchy may be called limited; but the limitations are of such a nature that the liberties of the people have been more secured by the mildness of the reigning family than by any restrictions that the states have or could exercise. The king enjoys the whole executive power, confirms pardons, bestows commissions, nominates the supreme judges, and enjoys the power of making peace and war, and of concluding all treaties. In making new laws, and in imposing new taxes, the states have the right to be consulted. According to the ancient constitution, which is still adhered to, the states are constituted of various ele-

ments; and, in fact, are an amalgama of various corporations, each of which thinks only of its own peculiar interests, and contrives to cast the weight of all public burdens from the cities and the nobles, who are represented, to the country people who have no voices. The assembly consists, 1st, Of members chosen by the provincial representatives of the nobility; 2dly, Of the representatives of the prelates, who, before the Reformation, had seats; but who have since been chosen by the higher class of nobles in right of their possessing certain estates of which the prelates were deprived; and, 3dly, The university of Leipsic. These states represent only the circles of Meissen, Leipsic, Erzgebirge, and Voightland; for that of Lusatia has its own peculiar assembly of states, which differs but little from those of the other four, except that the members from the land possessors must have at least sixteen quarterings in their coats of arms. When the king pleases these states are convoked; but, as it has not been found necessary to impose new taxes, or to make great alterations in the laws, they have seldom been assembled, and their session has usually been very short. The administration is conducted by a Cabinet Council, under which, through the medium of the privy council, orders are communicated to the departments of Finance, War, Domains, Police, and Foreign Affairs.

Revenue, Taxes, and Debt.

The revenue at present amounts to about L.1,250,000 Sterling annually. This revenue is derived in a great degree from royal domains, possessed by the government by ancient grants from the imperial court, or obtained by having been mortgaged and foreclosed for non-payment, or purchased by the ancestors of the present monarch. The royalties belonging to the crown furnish also a considerable share of this revenue; they consist of the mines, the forests, the fisheries, and of interest on money lent. The direct taxes are on land, on trades, various excise duties, stamp taxes, and tolls on roads, rivers, and bridges; the greater part of which fall exclusively on those who have no voice in the states. The whole public debt, including the cash notes (*Kassenbillets*), which did amount to L.550,000, but are now reduced to L.450,000, and circulate as freely as cash, is somewhat less than L.4,000,000; the interest on which is regularly paid, and a portion of the principal is annually discharged. The credit of no government stands higher than that of Saxony, and nearly the whole debt is due to its own subjects.

Forces.

The regular army of Saxony at present is reduced to 10,000 men, including cavalry, infantry, and artillery. Since the year 1817, when the regulars were thus reduced, there has been a register kept of the single men between 18 and 31 years of age, who form a kind of militia, and from among whom the troops of the line are chosen; from this conscription, however, the privileged orders are exempt. There are military academies in Dresden for instructing both the cadets of the line and those of the artillery.

Religion.

Although the royal family profess the Catholic religion, and are zealous in discharging its injunctions, the established faith is the Lutheran, and, until the year 1811, no person of any other sect was eligible to seats in the several corporations in the provincial or general assembly of the states. At that period all sects were placed on the same footing. The whole number of Catholics is about 40,000, some of whom are attached to the royal household; but most of them are found among the inhabitants of the province of Lusatia. The number of Protestants dissenting from the established church, including Moravians and Calvinists, is not supposed to exceed two thousand. The Lutheran church is regulated by four Consistories or Assemblies of divines; differing in the number of superintendents, but comprising together twenty-four of that order. The Catholics in Lusatia are regulated by the Abbot of Bautzen, on whom the Pope generally bestows the title of Bishop *in partibus infidelium*.

Education.

Education is well conducted in the university of Leipsic, and in the endowed classical schools of Meissen, Wurzen, and Grimma, as well as in several gymnasiums. The popular education is not so well managed as in the other Protestant German states; and some recent efforts to improve the system have not been attended with good practical results. The fine arts have been cultivated with considerable success; and both statuary and painting receive valuable assistance from the fine productions of both which the collections of Dresden contain.

See Leonhardi *Erdbeschreibung der Kurfürstlicke und Herzoglicke Sächischen Länder*. *Sachsen Dargestellt*, von K. F. Mosch. *Pölitz Geschichte und Statestik der Königreich Sachsen*. Jacob's *View of Germany*. (W. W.)

SCOTLAND.

The history of Scotland as a separate kingdom having been treated at considerable length in the *Encyclopædia*, all that we propose here is, to supply what is wanting in the imperfect account there given of its Statistics; referring, however, to our county articles for local description and details, and confining ourselves, for the most part, to such general statements as concern the industry, population, and resources of the nation at large.

I.—General Description of the Country.

Situation and Extent.

Scotland, the northern division of Great Britain, is situated between 54° 37′ and 58° 42′ north latitude, and between 1° 47′ and 6° 7′ west longitude,

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from Greenwich; having the sea on all sides, except the south, where it is separated from England partly by the Tweed, and other streams, and partly by a line supposed to be drawn along the high grounds in that quarter. Its greatest extent in the same longitude is from the Mull of Galloway, on the south, to Farouthead in Strathnaver, on the north, a distance of 275 miles; while its breadth from east to west varies from 36 to 147 miles; its area, calculated from Arrowsmith's map, being about 25,520 square miles of land, and 494 square miles of fresh water lakes. This is the extent of the Mainland only, exclusive of the islands on the west, called the HEBRIDES; and those of ORKNEY and ZETLAND on the north, which altogether are computed to extend over 4224 square miles. Including these islands, the northern limit of Scotland stretches beyond the 61st degree of latitude, and its longitude is between the meridian of London and 8° 18′ west; and its area comprehends 30,238 square miles, of which the fresh water lakes occupy 638 square miles, or about one forty-eighth part of the whole. The outline on the sea-coast is exceedingly irregular, and of great extent, the sea penetrating to a great depth, both on its eastern and western sides. Of these arms of the sea the most considerable are the Friths of Forth and Tay, and the Moray Frith, on the east; and the Frith of Clyde and the bays of Glenluce and Wigton on the west and south-west: along the northern and north-western coasts there are a number of smaller inlets, called lochs, which indent the country in all directions.

Face of the Country.

With the exception of narrow tracts along its principal rivers, there is very little of the country flat or level, and not a large proportion of the whole that would be deemed productive land in more favoured regions. Every where, even in the south, and along the east and west coasts of what is called the *Lowlands*, the surface presents great variety; in some places, gently rising from the sea, and the banks of the principal rivers, and spreading out into considerable tracts of fertile land; and in others projecting into the ocean, the termination of those ridges which traverse the interior, and which, a few miles from the coast, sometimes ascend to the height of 2000 feet. In this quarter of Scotland, a tract of mountainous country, known by various names, stretches in a south-west direction from the Cheviot hills of Roxburghshire, on the borders of England, to the Irish Channel, sending off branches on both sides; while detached hills frequently occur over all the low country. These high grounds, however, are for the most part clothed in green, almost to their summits, and have little of that wild and desolate character which distinguishes many of the mountains of the Highlands. Northward from the isthmus formed by the Friths of Forth and Clyde, the low grounds form but a small proportion of the whole. Here, in latitude 57°, the Grampians extend from sea to sea, with a breadth of from 40 to 60 miles; and parallel to them, to the south, is another and lower chain, called the Sidlaw, Ochills, and Campsie hills. Between these two ranges lies the fertile valley of Strathmore. Farther north, cultivation is mostly confined to the sea-coast, the banks of the larger rivers, and the narrow glens between the mountains. On the north-west, beyond the line of the Caledonian Canal, the country is, with few exceptions, singularly rugged and sterile, consisting of lofty mountains, either covered with heath, or presenting a mass of naked rocks, interrupted only by deep and dark ravines, lakes, and precipitous streamlets. Caithness, the north-eastern county of the Mainland of Scotland, is, nevertheless, generally low, but marshy and unproductive.

Mountains.

The elevation of the most considerable mountains of Scotland above the sea, with the counties in which they are situated, are stated as follows: (Playfair's *Scotland*, Vol. II. p. 341, and *General Report of Scotland*, App. Vol. I. p. 128).

Names.	Height in Feet.	Situation.
Benevis	4380	Inverness-shire
Benwyvis	4380	Ross-shire
Benmacdowie	4300	Aberdeenshire
Cairngorum	4060	Banffshire
Rona	3944	Zetland
Benlawers	3978	Perthshire
Schehaillon	3673	Ibid.
Hartfell	3302	Dumfries-shire
Benlomond	3262	Stirlingshire
Lowthers	3150	Lanarkshire
Goatfield	2950	Arran Isle
Hartfield	2800	Peebles-shire
Muirfoot Hills	1850	Edinburghshire
Ruberslaw	1419	Roxburghshire
Eildon Hill	1330	Ibid.
Soutra Hill	1000	Berwickshire
North Berwick Law	940	Haddingtonshire
Cockburn Law	900	Berwickshire
Arthur's Seat	822	Edinburghshire

To these heights we may add the site of the village of Leadhills, in Lanarkshire, 1564 feet above the sea. The land near this village is the highest cultivated land in Scotland. In Aberdeenshire the plough sometimes reaches the height of nearly 1300 feet. But with few exceptions, an elevation of 600 feet seems to be the limit to the tillage lands of Scotland. None of the Scottish mountains ascend to the line of perpetual congelation, yet snow may be found in some of their dark recesses, on which the sun never shines, all the year round.

Climate.

The climate of Scotland, as might be expected, from its insular situation and high latitude, is cold, cloudy, and wet. This is its general character, as compared with the greater part of England; yet, even in the south of England, frost is sometimes more intense, and snow falls more copiously, than in Scotland; and on the west coast of that country the quantity of rain is also greater. Corn, however, and most of the fruits and vegetables common to both divisions of Great Britain, attain maturity nearly a month sooner in England than in Scotland; and some plants, such as hops, and a few others, cannot be profitably cultivated at all in the latter country. The range of the barometer is 2.82 inches, or from 30.92 to 28.10 inches; in the Orkneys it is somewhat more, or about 3 inches. The lowest yearly temperature is 41° 11′, the highest 50° 32′, and the annual average

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for all Scotland may be between 45° and 47°. Of rain the average is about 31 inches; and the difference between the east and west coasts, in this respect, has been estimated generally at one-fifth more on the latter than on the former. The number of fair days on the west coast is only 160, while on the east it is 230. The prevailing winds in both situations are from the westerly points; but on the east coast it blows from the easterly points for about a third of the year. Easterly winds generally prevail in March and April, and often in May and part of June; and not only check vegetation. but occasion various slight disorders among the inhabitants.

For the purpose of exhibiting the distribution of heat and of rain throughout the year, we give the following abstract from a register of the weather kept near Perth, for the year 1820. The temperature is probably not very different from the average temperature of Scotland, but the number of rainy days, and the quantity of rain, are both considerably less than on the western coast.

	Fair Days.	Rainy Days.	Quantity of Rain.	Mean Temperature.
January	21	10	1.321	30.4
February ...	24	5	1.198	39.1
March	25	6	0.332	40.6
April	24	6	0.690	46.7
May	10	21	5.447	49.4
June	18	12	1.745	54.6
July	22	9	1.635	57.6
August	12	19	2.228	56.0
September ...	16	14	0.973	52.6
October	20	11	2.295	44.5
November ...	20	10	1.658	41.6
December ...	20	11	2.165	38.7
(*Edin. Annual Reg.* 1820.)	232	134	21.687	45.98

For an account of the mineralogy, zoology, and botany, and also of the rivers, lakes, and forests, of Scotland, see SCOTLAND in the *Encyclopædia*, and the *Scottish counties* in this *Supplement*.

II.—DIVISIONS.

Divisions.

The most natural and obvious, as well as the most ancient, division of Scotland, is into the Lowlands and the Highlands; a distinction marked by the difference in the language and dress of the people as well as by the surface of the country; though the line of separation between the two is by no means well defined. The friths or arms of the sea, which entering the land on both sides, leave but a comparatively small extent of country between their extreme points, present limits more distinct; especially since the execution of the two canals, which, being carried along these isthmuses, connect the eastern and western seas. These are the Forth and Clyde Canal between the friths so called; and the Caledonian Canal, now (1823) nearly completed, which runs from the Moray Frith on the north-east to Linnhe Loch on the south-west. The country to the south of the Forth and Clyde Canal has been called the southern division; that between the two canals the middle; and all to the north and north-west of the Caledonian Canal the northern division.

Counties and Parishes.

The divisions generally recognized are counties and parishes. Of the counties, the number is 33, most of which are again subdivided by local acts of Parliament into two or more districts in each, for the purposes of police and internal economy; and several of them comprise a variety of territorial divisions, founded on the natural circumstances of the country. Thus the county of Berwick is popularly divided into the three districts of the Merse, Lauderdale, and Lammermuir; Lanarkshire into the Upper, Middle, and Lower Wards; and, in the extensive Highland counties, the subdivisions are still more numerous. The number of parishes is at present 899, but liable to vary from annexations and disjunctions. Every country parish contains a church and burying-ground, with a *manse* or dwelling-house, and a few acres of land as a glebe, for the clergyman, who is always resident; and a school, with a schoolmaster's house and garden. In several of the towns one church has two ministers, so that the number of the clergy is greater than that of the parishes. In 1813, the parochial clergy amounted to 938, besides assistants and ministers of chapels of ease. An indefinite number of parishes form the ecclesiastical division, called a presbytery, and several presbyteries unite to compose a synod. We shall give the names and extent of these divisions under their proper head.

III.—INTERNAL COMMUNICATION.

Roads.

Until after the middle of last century there was scarcely any thing that deserved the name of a good road in Scotland. About the year 1732, indeed, Government began to open up the country by roads made by the military, hence called Military Roads, which extended in all about 800 miles; but these being confined for the most part to the Highlands, and intended only for military purposes, and formed with little or no regard to such ascents and descents as do not impede the passage of an army, were of little advantage to the more populous parts of the country. It is within the recollection of persons still alive, when corn, coals, and other heavy articles, were usually carried on the backs of horses, even in the southern counties of Scotland; the roads or rather the tracks being for the greater part of the year unfit for wheel-carriages. But so great a change has been made in this respect, particularly within the last forty years, that mail-coaches, and other carriages, now run day and night at the rate of from six to eight miles an hour through every part of the country, from the borders of England to Thurso in Caithness, the northern extremity of Great Britain.

The only funds formerly applicable to the making and the repairing of the roads in Scotland were what is called the *Statute-Labour*, or the labour of the occupiers of the land, for six days annually, on the roads passing through their respective parishes; and a small assessment imposed upon the proprietors.

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This labour, which has been converted into a payment in money, and also the sums raised by assessment on the proprietors, under the name of *road* and *bridge* money, are now applied to *bye-roads*, or such as communicate with the great turnpikes, or others calculated for the accommodation of the particular district in which the money is levied. Almost every county has procured an act of Parliament which fixes the rate of these assessments; but this varies in different counties, according to the circumstances of each.

The turnpike roads and bridges in the Lowlands have been made and are kept in repair by means of tolls exacted from those who use them, under the authority of private acts. The trustees named in these acts are commonly empowered to borrow money on the security of the funds to be received, by which means the work is executed more speedily, to the great advantage of the public. The expence of these roads depends so much upon local circumstances, that it has varied from L.1200 to L.100 *per* mile; but may be averaged at about L.400, the rate which the Highland roads, confessedly not so substantially made as the great roads in the Lowlands, have cost under the direction of the Parliamentary Commissioners. Of the road between Glasgow and Carlisle, conducted under the same superintendence, 39 miles, which was nearly finished in 1821, would cost, with its bridges, L.50,000, or L.1282 *per* mile. (*Ninth Report* of the Commissioners for Highland Roads and Bridges.)

Highland Roads and Bridges.

In the Highlands, the nature of the country, and the state of the population, did not admit of the same system as in the Lowlands. The military roads had not only been made, but were kept in repair at the public expence, for which L.5000 a-year was usually granted by Parliament; but a great many new roads and bridges were required; and, in 1803, an act was passed, proceeding upon "A survey and report of the coasts, and central Highlands of Scotland," by which Parliament agreed to provide half the estimated expence of the necessary roads and bridges; the other half to be defrayed by the landed proprietors; and Commissioners were named to carry into effect the beneficent intentions of the Legislature. It appears from the Report just referred to, that, under this act, the Commissioners had, in 1821, expended, on 875 miles of road, and several large bridges, upwards of L. 450,000, of which L.240,000 was granted by Parliament, and the rest defrayed by the counties through which the roads passed; and that L.100,000 more had been laid out by them on harbours, of which L.50,000 was paid out of the funds arising from the Forfeited Estates in Scotland, and the remainder was raised by the Burghs, and the contributions of individuals. If, to these sums, we add the amount of the losses sustained by the contractors, as stated in the Report, and the expence of the new roads made at the sole expence of the proprietors to communicate with the Parliamentary roads, together with the charges of repairs, the whole amount expended within these twenty years on the roads, bridges, and harbours of the Highlands of Scotland, may not be too high stated at a million Sterling. The Commissioners have under their charge both the maintaining of their own roads, and part of the military roads; the extent of the whole in 1821 being 1183 miles; and about L.10,000 a-year, of which L.5000 is granted by Parliament, was considered to be necessary for this purpose, including all charges of management.

Canals.

We have already mentioned the Forth and Clyde and Caledonian Canals, as affording the means of communication between the east and west seas. A full account of the former has been given in the *Encyclopædia* (see CANAL), and of the latter in this *Supplement*. On the Caledonian Canal, now nearly completed, there had been expended, in May 1822, L.884,159, 12s. $1\frac{3}{4}$d. (See *Nineteenth Report* of the Commissioners on the Caledonian Canal.) The other canals are the Crinan, cut across the peninsula of Kintyre at an expence of L.140,000; the Glasgow, Paisley, and Ardrossan Canal, of which only about a third part of the line, or 11 miles, is finished; a cut from the Forth and Clyde to Port-Dundas at Glasgow; the Monkland Canal, extending about 12 miles from Glasgow to the collieries in the parish of Monkland; a canal from the harbour of Aberdeen to Inverury, about 18 miles; and the Union Canal from Edinburgh to the Forth and Clyde near Falkirk. For a more particular account of these works, see the Scottish counties through which they pass in the *Encyclopædia*, and in this *Supplement*.

Railways.

Railways have not yet been carried to any great extent in Scotland. They are employed for a short distance at some of the principal coal-works and others; but the most considerable is that which has been carried from Kilmarnock to the harbour of Troon in Ayrshire, a distance of 10 miles, at the expence of the Duke of Portland, the proprietor of extensive coal-fields in that quarter.

IV.—VALUED AND REAL RENT—PROPORTIONS OF LAND CULTIVATED AND UNCULTIVATED.

Valuation of Lands.

About the middle of the seventeenh century, the lands of Scotland were valued, with a view to ascertain what proportion of the land, and other taxes, should be paid by each county; and this valuation, called the *Valued Rent*, which had been undertaken under the authority of Cromwell, was afterwards established by an act of the Scottish Convention in 1667. It is still the rule by which the counties, and the estates of each county, are assessed for payment of the land-tax, and all local imposts on land. The Table subjoined to this section exhibits, among other things, the valued rent of each county, as it stood in 1674, and the amount of the whole, namely, L.3,804,221 Scots, or L.317,018, 8s. 4d. Sterling. In 1811 this valuation was divided as follows:

Estates.

Description of the Estates.	Number of Proprietors.
Large properties or estates above L. 2000 of valued rent	396
Middling properties or estates, from L. 2000 to L. 500 of valued rent .	1077
Small properties or estates, under L. 500 of valued rent	6181
Estates belonging to corporate bodies	144
Total .	7798

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Tenures.

The land-rights of Scotland are still subjected to feudal tenures; and all the land is held either immediately or mediately of the Crown, as the paramount superior. The only distinction in regard to land-rights, which requires to be noticed here, is that between property which acknowledges no other superior than the Crown, and that which is held immediately of a subject; the right of voting in the election of the county representatives being vested in proprietors of the former class, while those of the latter, however large their estates, are wholly excluded. In general, to give a right to vote requires a freehold to the extent of L. 400 Scots of *valued rent;* but it is not necessary that the freeholder should have property in the soil to that amount; the mere feudal *superiority* of lands of that valuation, though seldom affording any income, is sufficient; for the lands themselves may, and in many cases do, belong to another. The number of voters in each county, at Michaelmas 1822, will be found in the table subjoined; but it varies, though not greatly, from year to year.

Rental.

The gross rental of the lands and houses of Scotland, according to the returns made under the late Property-tax act, for the year 1812, is exhibited in the same table. Of this, the rent of the *land* may amount to nearly five millions, which may not be far from the present revenue of the landed proprietors; for although many of the rents contracted for during the last years of the late war have been reduced since, yet others, upon the falling in of older leases, have been much advanced. As the common duration of the lease in Scotland is nineteen years, the average term of the current leases at any period must be between nine and ten years, so that half the leases current in the beginning of 1812 must have been entered into soon after the beginning of the century, and at such rents as would even now, considering the improvements that have been so generally made since, admit of some augmentation.

Leases.

This rent is paid by tenants; only a very small proportion being in the occupation of the proprietors themselves; and, with the exception of grazing lands near their seats, which are usually let for the season only, the tenants all hold on written leases for periods, varying from 12 or 15 to 21, and in some cases 38 years. These leases, with few exceptions, prohibit the tenant to sub-let his farm, either in whole or in part, without the consent of the proprietor; and upon the death of the tenant, the lease falls to his heir at law. Life leases were formerly very common, at least in those districts where the more improved system of agriculture had made little progress; but the extraordinary enhancement of prices during the late war had the effect of deterring landholders from letting out their estates for an indefinite, and, as it often proved, a very long term; and the practice, now almost obsolete, is not likely to be revived.

The rents are paid in money, and not, as in former times, in grain or other produce, or in services. Of late, since the great fall in the prices of land produce, it has become not uncommon to regulate the rent by the price of grain; the quantity and kinds of grain being fixed by the lease, and the rent, or the price of that grain, by the rates of the market; or more commonly by what is called the *Fiars*, or prices struck yearly, for certain purposes, by a jury in all the counties of Scotland. In some parts of the Highlands, where the land is still in some instances let out again by the principal tenant in small portions, the sub-tenants are required to perform certain sorts of work for the superior tenant; and on the shores of the western and northern islands the tenant may be said to pay his rent chiefly in kelp or in fish; but all these exceptions bear but a small proportion to the whole rent of Scotland.

Extent cultivated and uncultivated.

The main source from which rent is paid over the greater part of Scotland is live stock, principally cattle and sheep. Of the area, extending to 29,600 square miles, or 18,944,000 English acres, exclusive of lakes, little more than a fourth, or five millions of acres, are regularly or occasionally in cultivation; and about two-thirds even of this is employed in grazing and in raising crops for live stock, or is under fallow. According to the *General Report of Scotland,* drawn up for the Board of Agriculture, the extent yearly under corn, with beans and pease, is only 1,799,150 acres; of which 1,260,362 produce oats, 280,193 barley, and only 140,095 wheat; an estimate which is probably rather above the truth as to both oats and barley. The rest of the country, or nearly 14 millions of acres, is, after deducting about 900,000 acres, as the estimated extent of the natural and planted wood, still in a state of nature, and by far the greater part must always remain so. But much of this yields a valuable return under sheep, with a small proportion of cattle. For an account of these and the other kinds of live stock kept on the farms of Scotland, see AGRICULTURE in this *Supplement.*

It is little more than half a century since the management of tillage lands was conducted even in the Lothians and Border counties, according to the system which has now become pretty general over all the country. Previous to that period the mode of cultivation did not differ materially from that which, though falling into disuse, may still be met with in some of the Highland counties, and which we have described under these counties in this *Supplement.* Almost every where the practice was to take crops of grain successively, and then to leave the soil in a state of waste, till gradually invigorated again by time and the folding of the cattle. Such of the farmers as wished to learn better methods sought for this information in England, where agriculture was then in a much more advanced state than in Scotland; but in many parts of which it has long remained stationary, while that of Scotland has been always making some progress since, and within the last twenty-five years a very rapid progress. The crops cultivated (see AGRICULTURE in this *Supplement*) are now the same in both countries, with the exception of a few species, not of great importance, which the climate of Scotland does not bring to profitable maturity.

Value of Land Produce.

With regard to the capital invested in the agriculture of Scotland, and the amount of its yearly produce, of which little can be said with any great pretension to accuracy, we must refer to the Tables in the *General Report of Scotland,* Vol. III., which have been given in the last edition of the *Encyclopædia.*

Scotland. Taking the rental, exclusive of mines, quarries, and river fisheries, at $4\frac{1}{2}$ millions, and supposing that to be equal to one-third of the gross produce, a common estimate in most parts of Scotland, the amount of the latter would be $13\frac{1}{2}$ millions; but as lands in their natural state, depastured with sheep, certainly do not yield three times the rent, perhaps it would be nearer the truth to estimate the total annual produce of the soil, exclusive of mines, &c. at twelve millions.

The least proportion of cultivated land is in the counties of Selkirk, Sutherland, and Orkney, being only about six acres in the hundred; the greatest in the county of Haddington, or East Lothian, where not quite a fourth remains uncultivated; and the average of all Scotland is 26.6 in the 100. Including mines, quarries, and fisheries, the medium rent of the land may be a little more than 5s. an acre.

It is worthy of remark, that both the law and practice of Scotland are favourable to agricultural enterprise. Leases are almost universal, and of considerable duration. There is no tithe drawn; poor rates are unknown, except in a few districts, and where they do prevail, of a very trifling amount; and commons and common fields, for the division of which no act of Parliament is necessary, have, with very few exceptions, disappeared.

The titles of the columns in the following Table sufficiently indicate the contents of each. The rental for 1812 is the gross rental of the *Lands and Houses* as returned by the parties, or estimated by assessors acting under the Property-tax act.

Counties.	Extent.	Description of Land.		Valued Rent.			Rental in 1812.			Number of Freeholders, 1822.
	Acres.	Cultivated Acres.	Uncultivated Acres.	Scots Money.			Sterling Money.			
				L.	s.	d.	L.	s.	d.	
Aberdeen	1,254,400	451,584	802,816	235,665	8	11	301,098	14	8	188
Argyle	2,002,560	270,990	1,731,570	149,595	10	0	207,306	16	6	76
Ayr	664,960	325,830	339,130	191,605	0	7	369,742	10	0	181
Banff	412,800	123,840	288,960	79,200	0	0	85,212	4	1	36
Berwick	282,880	137,197	145,683	178,366	8	$6\frac{7}{24}$	236,224	19	3	131
Bute	103,040	29,440	73,600	15,042	13	10	20,955	2	9	15
Caithness	439,680	92,333	347,347	37,256	2	10	32,835	6	$5\frac{1}{2}$	29
Clackmannan	30,720	23,040	7,680	26,482	10	10	39,173	2	0	19
Cromarty	168,960	21,080	147,880	12,897	2	$7\frac{8}{12}$	*			15
Dunbarton	145,920	53,990	91,930	33,327	19	0	63,262	10	0	47
Dumfries	801,920	232,557	569,363	158,502	10	0	264,614	6	7	79
Edinburgh	226,560	144,999	81,561	191,054	3	9	713,431	11	10	178
Elgin	302,720	121,088	181,632	65,603	0	5	66,839	10	3	30
Fife	298,880	209,216	89,664	363,129	3	$7\frac{2}{12}$	378,757	5	8	241
Forfar	568,320	369,408	198,912	171,239	16	8	326,157	16	8	122
Haddington	174,080	139,264	34,816	168,873	10	8	213,329	15	0	102
Inverness	2,594,560	244,365	2,350,195	73,188	9	0	172,437	11	10	69
Kincardine	243,200	92,416	150,784	74,921	1	4	88,284	19	6	72
Kinross	46,080	27,648	18,432	20,250	4	$3\frac{2}{3}$	24,959	10	0	25
Kirkcudbright	525,760	168,243	357,517	114,597	2	3	192,046	10	10	148
Lanark	602,880	271,296	331,584	162,131	14	$6\frac{7}{12}$	616,434	11	1	164
Linlithgow	76,800	57,600	19,200	75,018	10	6	91,928	10	2	65
Nairn	124,800	37,440	87,360	15,162	10	$11\frac{1}{2}$	12,917	19	9	21
Orkney	819,200	46,368	772,832	57,786	0	$4\frac{5}{12}$	20,213	10	0	50
Peebles	204,160	24,500	179,660	51,937	13	10	60,099	0	0	46
Perth	1,656,320	530,022	1,126,298	339,892	6	9	512,336	13	8	222
Renfrew	144,000	72,000	72,000	69,172	1	0	234,777	0	0	153
Ross	1,677,440	149,895	1,527,545	75,043	10	3	111,857	3	8	87
Roxburgh	457,600	205,920	251,680	314,663	6	4	242,179	10	1	138
Selkirk	168,320	10,100	158,220	80,307	15	6	41,162	10	0	38
Stirling	312,960	195,600	117,360	108,509	3	$3\frac{1}{12}$	207,236	8	8	118
Sutherland	1,122,560	63,045	1,059,515	26,093	9	9	28,458	8	4	23
Wigton	288,960	101,136	187,824	67,641	17	0	131,778	12	10	59
Totals	18,944,000	5,043,450	13,900,550	3,804,157	19	$2\frac{9}{24}$	6,108,050	2	$1\frac{1}{2}$	2987

V.—Mines and Fisheries.

Scotland is not deficient in the most useful minerals. It has coal, iron, lead, with excellent stones for building and paving, slate, limestone, and marble.

Coal. Its great coal-field, stretching across the country in a diagonal line from west to east, or from the Frith of Clyde at Dunbarton to St Andrews, in Fife, and Haddington, in East Lothian, is about 98 miles

* The rental of this small county is included in that of Ross-shire, in which its lands are interspersed.

long, with an average breadth of 33 miles, and estimated to extend over 600,000 acres. Coal has also been found to the north, in the county of Sutherland, and in Dumfries-shire and Roxburghshire on the south; but owing to situation, or to its inferior quality, it is not worked in either quarter to any considerable extent. Hence, though at the present rate of working, it has been calculated that the great coal field would last 3000 years, yet a large portion of the country is but indifferently supplied with this necessary of life in so cold a climate. In the Highlands and Isles, peat or turf is the most common fuel, and the only sort to which the lower classes have access; and in the south and south-west coals are imported largely from Newcastle and Whitehaven, by sea, and from the borders of Northumberland by land carriage. On the other hand, Scotland exports to Ireland and other parts to a still greater amount, and some of her best kinds begin to find a ready market even in England. The Scotch coal differs from the English in its rising in large masses, which do not adhere or cake together in burning; and though it makes a more cheerful fire it is not so durable, and the common kinds leave more ashes than the English. Some of the fusing or caking coal is occasionally met with in the same pits with the other kind, but it bears a small proportion to the whole. The quantity consumed in the country is stated to be about two and a-half millions of tons, of which two millions are supposed to be required for domestic purposes, and the remainder for the iron and lime works and other manufactures; and the price which, in 1813, was averaged at the pit-mouth at 6s. 8d. the ton, may be less at present by 10 or 15 *per cent*. After paying all charges at the works, the coal owner's share of the price does not exceed 1s. a ton.

Iron.

Iron is very generally found, particularly in the coal districts, and is wrought to a considerable extent; though a great deal is still imported, chiefly from Wales. The greatest manufactory is near Falkirk, well known by the name of the Carron-works. A few years ago there were in all 21 blast furnaces in Scotland, producing about 33,000 tons annually, and giving employment to 7650 people.

Lead.

Lead, which occurs in many parts of Scotland, is wrought to the greatest extent at Leadhills and Wanlockhead, on the confines of the counties of Lanark and Dumfries, where between 3000 and 4000 tons are raised yearly. The number of people in these two villages, the most elevated in Scotland, employed in and supported by the labour of the mines, is about 2000. Other mines, upon a small scale, have been long worked in the isle of Isla, one of the Hebrides, and on the west coast. The produce of the whole has been estimated at L. 136,000, of which the proprietor has a sixth part, and the contractor, or lessee, who bears all the charges, the remainder. The silver obtained from the lead varying from six to seventeen ounces for every ton, is said to be worth about L. 10,000 a year, and is now extracted at home instead of being sent to Holland for that purpose, as was the practice till within the last thirty years.

Stone.

Granite, sandstone, basalt, and other stones, are so abundant, that in every district one or more kinds is at hand for building, paving, inclosing, and other purposes; but it is only near large towns that the quarries afford any considerable rent to the owners. Those in the neighbourhood of Edinburgh, from which the freestone of the elegant buildings in the New Town is procured, rented at about L. 10,000 *per annum* more than twenty years ago. The most beautiful and durable species of freestone in the kingdom is that furnished by the quarries at Culello, in Fifeshire. Slate is wrought extensively at Easdale, one of the Hebrides, at Balachelish, in Argyleshire, and other places. Limestone, producing in all about 12,000,000 of bushels of slacked lime, worth upwards of L.350,000, is wrought in various parts, but chiefly in the neighbourhood of the coal-works. About 100,000 acres are supposed to be dressed every year with this important manure. Marble is found in the Hebrides, on the west coast of Argyleshire, and in Sutherland, but often blended with other minerals, which injure its appearance, and render it difficult to work. A pearl fishery on the Tay is said to have yielded L. 10,000 annually for a few years, but has produced little or nothing for more than half a century. Marl has a local value as a manure, but the quantity that must be applied to land is too great to admit of its being used at a distance from the spot where it is found.

Slate. Limestone. Marble, &c.

Mineral Waters.

Mineral waters, of various qualities, occur in many parts of Scotland. Those which have been long in most repute, and still maintain their character, are found at Moffat, in Dumfries-shire, and Pitcaithly, in Strathearn, in the county of Perth.

Fisheries.

The fisheries form a very important article in the productive labour of Scotland; the annual value of the whole having been estimated, ten years ago, at near a million and a half Sterling. Since that time the herring fishery, which was then stated at half a million, has been progressively increasing; and the repeal of the duties on Scotch salt in the last session of Parliament (1822), must afford encouragement, especially to the small fishermen on the coast, who felt themselves so much annoyed by the excise regulations, to prosecute both that and the other fisheries to the utmost extent of the market; for as to the supply it is held to be inexhaustible. But, for a particular account of this great branch of national industry, we must refer to the Article FISHERIES in this *Supplement*, and also to the Article ORKNEY, where notice has been taken of a productive cod bank lately discovered in that quarter.

VI.—MANUFACTURES, COMMERCE, AND SHIPPING.

Manufactures.

Since the Union with England, and more especially since the close of the American war of independence, Scotland has enjoyed a full share, in proportion to her wealth and population, of the manufactures and commerce of Great Britain. There is scarcely a single branch of either in which she does not participate, while in some articles, such as linen and spirits, she has long been in advance of England, and has one or two others almost peculiar to herself.

As several of the Tables given under this head in the Article ENGLAND, in this *Supplement*, embrace Scotland as well as England, for which, in some instances, it would be impracticable to exhibit separate articulate statements, we must refer the reader to that article,

Scotland.

and confine ourselves at present to a general view of such branches belonging to Scotland as are common to both countries; giving some further notices of others which are more properly of a Scottish character.

Woollens.

Of the manufactures, that of woollen, carried to so great an extent in England, has never made much progress in Scotland. A variety of articles, of a coarser description, are made for domestic consumption in country families; and a number of small establishments have been formed in different parts, where machinery is employed, and the several processes of the English manufacture, from the raw material to the finished fabric, are adopted with considerable success. But most of the wool grown in the country is still exported to England, and almost all classes of the people, at least in towns, use English broad cloth, flannels, and blankets, in preference to their native fabrics. Carpeting is made to some extent at Kilmarnock and a few other places; tartans in the county of Stirling; and Shetland has been long noted for its hosiery.

Cottons.

The cotton manufacture, though not half a century old, has been much more successful. Its principal seat is in Lanarkshire and the western counties adjacent, where it is conducted in its various branches to such an extent, as to give employment to about 150,000 hands, of whom 90,000 are women and children. The value of the goods produced was estimated, in 1812, at near seven millions Sterling. In 1818, Glasgow and its neighbourhood furnished to the amount of more than five millions, about half of which was exported. For a particular account of this great branch of industry, see the Article COTTON MANUFACTURE in this *Supplement*.

Linens.

Of the linen manufacture of Great Britain, Scotland has by far the greatest share. In 1727, a Board was established at Edinburgh under the authority of an act of Parliament (13th Geo. I.), for the regulation and encouragement of the linen and hempen manufactures. Since 1812, according to a Return made to Parliament (ordered to be printed 3d July 1823), this Board has had an income of about L. 8000 a year, of which it expended annually between L. 3000 and L. 4000 for this purpose, and in premiums to the growers of the raw materials. Among other regulations it was till lately required, that all the linen cloth made for sale should be stamped by officers appointed by the Board; but this regulation was abolished by the act of the 4th Geo. IV. cap. 40, passed in June 1823. The quantity and estimated value, every tenth year, from 1730 to 1810, are as follows:

Years.		Total Yards.	Total Value.		
			L.	s.	d.
1730	Under 9d.	3,755,622¼	131,262	15	11¾
1740	Do.	4,609,672¾	188,777	16	5½
1750	Above 9d.	7,572,540¼	361,736	12	5¾
1760	Do.	11,747,728¾	523,153	10	5
1770	Above 1s.	13,049,535	634,411	7	1½
1780	Do.	13,410,934¼	622,187	16	4½
1790	Under 1s.	18,328,257¾	729,748	16	5¼
1800	Do.	24,235,633½	1,047,598	10	10
1810	Do.	26,457,079¾	1,265,669	17	2

After 1810, this branch seems to have declined. In 1811, the quantity stamped was less by about five millions of yards, and in 1812 it was further reduced by about two and a half millions. Since the peace it has participated in the fluctuation, to which almost all the other branches of our industry have been exposed, but has of late increased very much, and is now in a prosperous state.

Very little of the linen is of a fine quality; it consists chiefly of sheetings, osnaburghs, bagging, &c. the average price not exceeding 1s. a yard. The finer kinds are either made in private families or imported from Ireland. The counties of Aberdeen, Fife, and Forfar, carry this manufacture to the greatest extent, having about four-fifths of the whole. Machinery has been extensively employed since 1790, but it has not yet been found applicable to the finer qualities of yarn, which are still spun by hand.

Sail Cloth.

The royal navy, during the late wars, was chiefly supplied with sail cloth from Scotland. In 1812, the whole quantity made for this purpose, for private shipping, and for exportation, was estimated at 6,750,000 yards, worth about L. 300,000. This article is not included in the returns made to the Board.

The total value of the linen and hempen manufactures of Scotland, about the end of the war, including the yarn exported to England, has been stated at L. 1,775,000; but with what was made for private use and not stamped, of which no accurate account can be given, the whole perhaps amounted to about two millions Sterling, and is now estimated at near three millions.

Flax and Hemp.

As very little flax, and scarcely any hemp, are grown in Scotland, the raw materials must be imported; the flax chiefly from Holland, and the hemp from Russia; the prices of which, during the latter years of the late war, bore a large proportion to the value of the manufacture.

In 1812, the imports of these articles into Scotland, and their value, were as follows:

	Quantity.					Value.		
	Tons.	*cwt.*	*qrs.*	*lb.*		*L.*	*s.*	*d.*
Flax	6094	4	2	18	@ L.100 ℔ ton	609,423	6	1½
Hemp	2496	17	1	18	@ L.90 ℔ ton	224,718	7	0½
	8591	2	0	8	Amounting to	834,141	13	2

Export of Linens.

Since the peace, these prices have been greatly reduced, and the import of flax is almost doubled; but the export trade has increased in the same proportion, as appears from the following statement. (*Customhouse Returns*, 13th May, 1823.)

Years.	Official Value.		
1812	L. 831,854	11	1
1814	1,115,304	19	4
1815	1,071,951	15	2
1816	1,089,518	5	8
1817	1,451,661	5	0
1818	1,675,838	5	2
1819	1,236,142	16	8
1820	1,438,501	19	4
1821	1,701,709	18	4
1822	1,933,152	2	5

Scotland.

These are the exports of British linens, no separate account being kept of what are made in England and in Scotland; but by far the greater part is of Scotch manufacture.

The countries to which these exports were made in the years 1821 and 1822 are as follows: (*Parliamentary Paper*, ordered to be printed 22d May 1823.)

Countries.	1821.			1822.		
	L.	*s.*	*d.*	*L.*	*s.*	*d.*
Portugal, the Azores, and Madeira	53,597	1	8	40,627	9	5
Spain and the Canaries	24,624	15	7	78,812	7	0
Gibraltar	159,849	12	10	162,685	2	7
Asia	22,454	12	0	29,026	4	2
Africa	15,454	14	0	6,268	8	0
British North America	48,639	10	5	75,324	19	4
——— West Indies	552,391	18	3	542,947	4	9
Foreign West Indies	193,911	8	10	161,164	19	10
United States	442,204	18	7	516,781	3	1
Brazils	116,247	11	1	179,387	15	5
Foreign Colonies on Continent of North America	53,982	11	5	115,206	0	6
All other Parts	18,351	3	8	24,920	8	4
	1,701,709	18	4	1,933,152	2	5

Bounty on Linens.

A bounty is paid on the export of linen cloth according to its value; below 5d. the yard, a halfpenny; from 5d. to 6d., a penny; and from 6d. to 1s. 6d., one penny halfpenny. On linens above 1s. 6d. *per* yard there is no bounty. The bounty is allowed on English and Irish linens as well as Scotch.

Malt and Spirituous Liquors.

Malt liquors and spirits are made in great perfection in Scotland; and, notwithstanding the frequent alteration of the laws by which this manufacture is regulated, and a corresponding fluctuation in the trade itself, it has long formed a most important branch of the national industry. From 1786 to 1800, the quantity of malt made in Scotland varied from 1,500,000 to 2,000,000 of bushels yearly; the ordinary rate of duty being then $7\frac{7}{8}$d. *per* bushel. In 1804, when the duty on malt made from barley was raised to 3s. $8\frac{1}{8}$d., and from bear or bigg to 3s. $0\frac{1}{8}$d., the number of bushels fell to 1,125,482, and never reached 1,500,000 while these duties remained in force. In 1817, 1818, and 1819, when the duty was 1s. $8\frac{1}{8}$d., the quantity increased from $1,129,992\frac{5}{10}$ to 1,556,586 bushels. But in 1820, when it was raised to 3s. 6d., the number of bushels fell to $1,284,918\frac{3}{4}$. In 1822, under new modifications of the duty, it was 1,347,432 bushels; and for the year ending 5th April 1823, the number had increased to 2,150,795 bushels; of which $1,816,691\frac{1}{2}$ were made from barley, and $334,103\frac{1}{2}$ from bear or bigg. Nothing can afford a more striking proof of the unproductiveness, as well as the impolicy of a tax, when carried to an extreme. In 1792, the number of bushels was upwards of 2,000,000, and, at that rate, allowing for the increase of population, it should have been almost 3,000,000 in 1822, instead of being, as it actually was, less in 1822 than 1792 by one-third.

The quantity of beer and ale made in Scotland in 1822 was near 350,000 barrels, less by almost 3000 barrels than in 1792. The exports to England for the four years ending with 1820 was about 13,000 barrels yearly. Before 1801 it was seldom more than 500 barrels.

The duties and regulations affecting the Scotch distilleries have been so often altered, and even the principle itself according to which the duty is imposed, that it becomes difficult to exhibit an intelligible comparison between different periods without more explanation than our limits will permit. But some notion may be formed of their importance from the following account, which embraces three different rates of duty, and shows the influence of each on the quantity produced, and the revenue derived from it. The spirits are those made for home consumption only, not partly for the English market, and all made from grain or malt; no sugar or molasses being used in those years. (*Report on the Malt Duties of Scotland*, May 1821.)

Dates.	Gallons of Spirits made and charged with Duty.	Rate of Duty *per* Gallon.	Total Revenue produced.		
			L.	*s.*	*d.*
From 10th Dec. 1813 to 1st Oct. 1814	1,653,735	7s. $1\frac{41}{45}$d. in Lowlands, 5s. $11\frac{1}{3}$d. in Highlands	587,781	8	$1\frac{1}{2}$
1st Oct. 1814 to 9th Nov. 1815	$1,784,943\frac{1}{4}$	8s. $4\frac{2}{5}$d.	743,506	0	3
Year ending 10th Nov. 1816	$1,030,772\frac{3}{4}$	8s. $4\frac{2}{3}$d.	427,658	16	$8\frac{1}{2}$
——— 1817	$2,139,207\frac{1}{4}$	5s. $6\frac{1}{7}$d.	599,168	3	$5\frac{1}{2}$
——— 1818	$2,367,914\frac{1}{4}$	5s. $6\frac{1}{7}$d.	663,464	16	4
——— 1819	2,366,998	5s. $6\frac{5}{26}$d.	658,773	18	$4\frac{3}{4}$
——— 1820	2,167,558	5s. $6\frac{5}{26}$d.	602,676	18	$6\frac{1}{2}$

Scotland.

For the quantity of spirits made in Scotland for the English market, and exported to that country, see the Article England in this *Supplement*.

Besides the spirits which pay duty, illicit distillation, carried on in most of the Highland counties, supplies not a small proportion of the home consumption; the produce, from its being generally of a finer quality, finding its way, in spite of the vigilance of the revenue officers, into every part of the country. But the act passed in July 1823 (4th Geo. IV. cap. 94), by which the duty on spirits is greatly reduced, will leave so small an advantage to the illicit distiller, that he will probably find it no longer for his interest to persist in a course which has been the cause of so many evils both in this country and in Ireland.

Breweries and Distilleries.

Breweries have been established in all the towns of Scotland, among which those of Edinburgh, Alloa, and a few others, are in high repute. The principal distilleries are in the Lothians and the counties of Stirling, Fife, and Clackmannan. The business of the maltster being rarely a separate one, is combined with that of the distiller and brewer, the malt being generally made at the works where it is to be used.

Of the other manufactures of Scotland we must confine ourselves to a very brief notice. We have already mentioned her iron-mines, and the quantity produced yearly; to which we may add, that there are about 50 founderies, where it is converted into a great variety of agricultural and domestic implements and machinery, of which the export to America, the West Indies, and the other British colonies, is considerable; but the finer branches of the iron manufacture, such as locks and hinges, cutlery, &c., are not carried to any great extent. The silk manufacture, about fifty years ago, was prosecuted to a considerable amount in Paisley, but is now of little importance. Among the other articles, we may mention paper, glass, soap, culinary salt, and leather, which, with many others, though not singly of much interest, afford employment to a great many hands, and produce altogether a large sum.

Kelp.

The simple process of burning sea-weed into kelp, and the value of the article, form an important branch, especially in the Western and Northern Isles. About 80,000 people, of all ages, it is calculated, are employed in or dependent on this rude manufacture. The kelp is made during the summer months by the same people who afterwards engage in the herring fishery. The quantity has been stated variously, but, in favourable seasons, may probably amount to 16,000 tons; the best of which, during the late war, when the price of barilla was very high, brought upwards of L. 20 *per* ton. But since the peace, the price has been so much reduced, that it will do little more than pay the expence of the labour required, which may average between L. 3 and L. 4 *per* ton. Some of the Highland proprietors draw the greater part of their income from their kelp shores, and it is by their labour in making the kelp that many of the small tenants are enabled to pay their rents.

Commerce.

The commerce of Scotland with the British colonies, and with foreign countries, is included in that of Great Britain given in the Article England in this *Supplement*. Scotland trades with the same countries as England, and the articles she exports are, for the most part, of the same description. From Leith, Dundee, Aberdeen, and a few other ports on the east coast, a considerable trade is carried on with Sweden, Russia, the shores of the Baltic, and Holland; but the principal part of her foreign and colonial trade centres in the Clyde, which is the great emporium of the trade with the West Indies and America, and also with Ireland.

The trade between Scotland and England must be to a large amount, but as that part of it which is carried on by land does not appear in the Custom-house books, it does not admit of being estimated with much accuracy. Scotland sends to England exclusively cattle, sheep, and wool, and home-made spirits, and a large proportion of her other exportable produce and manufactures, such as corn, kelp, salmon, linen goods, &c.

Banks.

Intimately connected with the trade are the banking establishments of the country, which are numerous, substantial, and liberal in their dealings. Three of them, having their head offices in Edinburgh, and a great many branches throughout the country, were established by charter; namely, the Bank of Scotland, the Royal Bank of Scotland, and the British Linen Company. These, with several private banks in Edinburgh, Glasgow, and other large towns, issue notes, receive deposits, discount inland bills at three or four months date, and pay and receive sums so low as L. 10 on cash accounts. On money deposited with them, and also on what is paid in on the cash accounts, they invariably allow interest, though at a less rate than they charge themselves. As there is no limitation as to the number of partners, the credit of the Scotch banks is above all suspicion; and even with such of them as have stopped payment, a thing which very rarely happens, the loss has fallen upon the partners—very seldom, and to a very small amount, upon the public. The circulating medium of the country is almost entirely composed of the notes of these banks.

Shipping.

The registered vessels belonging to Scotland, with the amount of their tonnage, and the number of men and boys usually employed in navigating them, on the 30th September 1820, 1821, and 1822, were as follows:

	Vessels.	Tons.	Men.
1820	3133	288,770	20,470
1821	3160	289,535	20,855
1822	3071	276,931	19,831

The number of vessels, with the amount of their tonnage, built and registered in Scotland in the years ending 5th January 1821, 1822, and 1823, will give an idea of the extent to which ship-building is carried on; and to show that it has more than its proportional share of this trade, we subjoin the same account for England.

	1821.		1822.		1823.	
	Vessels.	Tonnage.	Vessels.	Tonnage.	Vessels.	Tonnage.
England	461	54,014	399	46,296	442	43,212
Scotland	121	11,004	122	9,457	87	6,162

Steam-Boats.

The intercourse between the different parts of the United Kingdom has been greatly facilitated by the recent invention of Steam-Boats. On the east coast of Scotland, there is a cheap, speedy, and regular communication by this means between all the principal towns, and between Leith and London, and the intermediate ports in England, for the greater part of the year; and on the west coast, besides those which ply on the Clyde between Glasgow and Greenock, vessels of this description sail between Glasgow and Liverpool, and cross the Channel to Ireland. Hitherto, passengers have been the principal object, and the hours of departure and arrival are almost as regular as those of the mail-coaches. The voyage between Leith and London is often made in about fifty hours, and the ordinary rate of sailing on the Forth and Clyde is from eight to ten miles an hour.

VII.—Education—Religious Instruction—The Poor.

Parish-Schools.

By an act of the first Parliament of William and Mary, it was provided, that "there be a school and schoolmaster in every parish" of Scotland; the salary of the schoolmaster to be not under 100 merks, nor above 200. In 1803 the lowest salary was fixed by another act at 300 merks (L. 16, 13s. 4d.), and the highest at 400 (L. 22, 4s. 5d.), besides a dwelling-house of at least two apartments, and a quarter of an acre of ground for a garden. At all these schools, reading, writing, and arithmetic are taught, and at many of them the classics and the French language, with geography, and some branches of the mathematics. The fees paid by the scholars in the country parishes, in addition to the salary, vary from 1s. 6d. to 5s. the quarter; but the master is obliged to teach the children of the poor on the recommendation of the kirk-session, *gratis*. The school, and schoolmaster's house and garden, are provided by the parish by assessments on the land; and one half of the salary is payable by the proprietors, and the other half by their tenants. These schools are under the inspection of the presbytery in which they are situated, who visit and examine them yearly. So generally have the lower classes availed themselves of this primary source of instruction, that an adult male, a native of the Lowlands of Scotland, who is ignorant of the common rules of arithmetic, is very rarely to be met with; and there are but few females who have not been taught to write as well as to read. In the Highlands and Isles, however, where many of the parishes are of great extent, and the intercourse is obstructed by the nature of the country, the case is very different. In some of these, half the inhabitants cannot read, and from the same causes the means of religious instruction are scanty, and of difficult attainment.

The Society of Scotland for *Propagating Christian Knowledge*, and the Committee of the Church for applying the Royal bounty, have done much, in both respects, by means of missionaries, catechists, and schoolmasters. Every year at the meeting of the General Assembly, the Sovereign, through his representative, the Commissioner, presents to this Court an order for L. 2000, to be employed in these useful labours.

Besides the parish-schools, a great many private schools are supported by the fees of the pupils alone. Of these, there is one or more in all the towns and villages of Scotland; and in the principal towns are found academies, and other seminaries of a higher order, besides the universities of Edinburgh, Glasgow, Aberdeen, and St Andrews. (See these towns, and also Scotland in the *Encyclopædia*, and Edinburgh and Glasgow in this *Supplement*.) Sunday schools, and those taught after the manner of Bell and Lancaster, are therefore less wanted here than in most other countries. Yet about 500 Sunday schools were reported to the General Assembly in 1818, and, including those of Edinburgh and Glasgow, the number of scholars was then upwards of 25,000.

The Church.

For a particular account of the Church establishment, we must refer to Scotland in the *Encyclopædia*, and confine our notices here to its present state, in so far as it differs from its former. In 1818 the number of presbyteries and parishes which compose each of the synods were as follows:

No.	Synods.	Presbyteries.	Parishes.
1	Lothian and Tweeddale	7	104
2	Merse, or Berwick and Teviotdale	6	66
3	Dumfries	5	53
4	Galloway	3	37
5	Glasgow and Ayr	7	127
6	Perth and Stirling	5	78
7	Fife	4	66
8	Forfar and Mearns	6	75
9	Aberdeen	8	97
10	Moray	7	52
11	Ross	3	23
12	Sutherland and Caithness ...	3	23
13	Argyle	5	39
14	Glenelg	5	29
15	Orkney	4	30
		78	899

Stipends of the Clergy.

The stipends of the clergy, the amount of which varies from year to year with the prices of grain, afford a moderate competence to all, but affluence to none. Throughout the country parishes, in seasons of average prices, the medium amount may be about L. 200 a-year, with a good dwelling-house, and a glebe, worth at least L. 50 more. In 1810 all the stipends below L. 150, which, from the want of free tithe, could not be augmented by the Commissioners of Teinds, were, by the 50th Geo. III. cap. 84, raised to that sum; the deficiency, which amounts to about

Scotland. L. 10,000 a-year, being supplied by Parliament This, therefore, is the minimum stipend in the church of Scotland, though, from very low prices of corn, some of those that do not partake in this bounty may occasionally fall below it. Out of 899 parishes, this augmentation was required for 172, or 1 in $5\frac{1}{4}$.

Dissenters. The Dissenters from the Established Church do not amount to a fourth part of the population, and two-thirds of them differ from it rather in matters of discipline than in doctrine. The most numerous classes of Dissenters are the Burghers and Antiburghers (recently united), and the Relief denomination. The other dissenters are Roman Catholics, Episcopalians, Methodists, with a few hundred Quakers, and a very small number of Jews. All these sects have their own places of worship, to which they resort in preference, though few of them exclusively. They mix freely in society, and their children, at least all those whose parents are of the Presbyterian persuasion, are taught at the same schools; little or nothing now remaining of that religious animosity which was once so prevalent in this country.

The Poor. The poor of Scotland are provided for partly by rates levied under the authority of the laws, but chiefly by voluntary contributions; and altogether, both their number, and the sums applied to their relief, are comparatively inconsiderable. In the country parishes, the sum to be raised by assessment is fixed by the land-owners, or heritors, and paid in equal proportions by themselves and their tenants; and in the towns the rate is levied from the inhabitants according to the rent of their dwelling-houses, or the estimated value of their property. The voluntary contributions consist of collections at the church-doors, fees paid at marriages and baptisms, and other small sums under the management of the Kirk-Session; to which in many parishes there is added, in seasons of peculiar pressure, such as a year of scarcity and high prices, a sum raised from the heritors and their tenants, upon the same principle as the legal assessments. In addition to these funds, some of the greater proprietors occasionally bestow donations in money, oatmeal, and coals, to be distributed under the inspection of the clergyman, or his elders; and not a few of the parishes have had bequests made to them for the maintenance and education of their poor, the interest of which forms the greater part of the yearly disbursements.

The following results, taken from the "General Abstract of the Population, Poor, and means of maintaining the Poor in Scotland," subjoined to the *Supplementary Report* of the General Assembly laid before Parliament in 1820, present the best information we have access to on this interesting subject:

Population for which the returns were made	1,764,987		
Number of paupers	44,199		
Proportion of paupers to population	1 to $39\frac{9}{10}$		
Assessments	L. 49,718	10	$5\frac{3}{12}$
Collections, and other voluntary payments	64,477	7	$3\frac{9}{12}$
Gross funds	L. 114,195	17	9
Sum which each pauper costs	L. 2	11	8
Expence to each individual of the population	0	1	3

As this Report was prepared little more than a year before the last census, the proportion of paupers to the population, and the expence that falls upon each individual, is stated too high. On the population of 1821, the proportion will be *one* pauper to $47\frac{3}{10}$, and the expence 13d. for each individual of that population. If the whole sum applied to the relief of the poor were raised by a rate on the lands and houses, it would be equal to about L. 1, 18s. *per cent.* of the rent in 1812 (see preceding Table, containing the Extent and Rental of Scotland); or about $4\frac{1}{2}$d. *per* pound of that rental. The returns from which the Assembly's *Report* was prepared were complete, with the exception of twenty Highland parishes, having a population (in 1811) of 36,290.

Friendly Societies and Savings Banks. According to other returns made to the Assembly in 1818, the number of Friendly Societies, exclusive of those of Edinburgh and Glasgow, amounted to 327, composed of 72,153 members; and with the same exclusion, 130 Savings Banks were reported, having 7000 contributors, and deposits to the amount of L. 30,000. It is stated, on the same authority, that a capital of L. 10,082, with L. 2034 of interest, was *mortified* for the support of the poor; and L. 100,750 of capital (including L. 70,000 lately bequeathed to the country parish of Dollar, in Clackmannanshire), and L. 793 of interest for their education. These sums do not include the funds of the great hospitals, of which an account will be found under EDINBURGH and the other towns in the *Encyclopædia* and in this *Supplement*.

VIII.—POPULATION.

The population of Scotland was taken, though not by authority, in 1755; and the writers of the *Statistical Account* afford the means of estimating its amount about 1798, when it appears to have been less by 72,576 than in 1801. But in the following Table, we shall confine ourselves to the three enumerations made under the authority of Parliament; presenting only the totals for 1801 and 1811, but giving that of 1821 under separate heads. The Table also shows the extent of every county in square miles, the increase of its population from 1801 to 1821, and the rate *per* square mile in 1821:

Scotland.

Counties.	Extent in Square Miles, exclusive of Lakes.	Population in 1801.	Population in 1811.	Population, 1821. Males.	Females.	Totals.	Inc. *per cent.* 1801 to 1821.	Rate *per* Square Mile.	Occupations. Families. Agriculture.	Trade.	All Others.
Aberdeen	1960	123,082	135,075	72,383	83,004	155,387	26.2	79.3	13,775	16,029	5,897
Argyle	3129	71,859	85,585	47,775	49,541	97,316	35.4	31.1	8,989	3,468	5,852
Ayr	1039	84,306	103,954	61,077	66,222	127,299	51.0	122.5	6,207	15,008	5,430
Banff	645	35,807	36,668	20,193	23,368	43,561	21.6	67.5	4,150	2,939	2,796
Berwick	442	30,621	30,779	15,976	17,409	33,385	8.9	75.5	3,334	1,923	1,908
Bute	161	11,791	12,033	6,474	7,323	13,797	17.0	85.7	1,314	730	811
Caithness	687	22,609	23,419	14,196	16,042	30,238	33.7	44.0	3,052	2,188	704
Clackmannan	48	10,858	12,010	6,356	6,907	13,263	22.1	276.3	434	1,418	1,029
Dumbarton	228	20,710	24,189	13,046	14,271	27,317	31.9	119.8	1,168	2,602	1,571
Dumfries	1253	54,597	62,960	33,572	37,306	70,878	29.8	56.6	4,340	4,706	5,412
Edinburgh	354	122,954	148,607	87,759	103,755	191,514	55.8	541.0	4,830	18,700	16,939
Elgin	473	26,705	28,108	14,292	16,870	31,162	16.7	65.8	2,676	2,330	2,321
Fife	467	93,743	101,272	53,540	61,016	114,556	22.2	245.3	5,260	13,748	6,741
Forfar	888	99,127	107,264	52,071	61,359	113,430	14.4	127.7	5,114	15,348	6,256
Haddington	272	29,986	31,164	16,828	18,299	35,127	17.1	129.1	3,009	2,947	1,978
Inverness	4054	74,292	78,336	42,304	47,853	90,157	21.3	22.2	10,215	2,447	5,662
Kincardine	380	26,349	27,439	13,540	15,578	29,118	10.5	76.6	3,025	2,301	1,359
Kinross	72	6,725	7,245	3,660	4,102	7,762	15.4	107.8	446	735	646
Kirkcudbright	821½	29,211	33,684	18,506	20,397	38,903	33.2	47.3	3,047	2,238	2,627
Lanark	942	146,699	191,752	115,385	129,002	244,387	66.6	259.4	4,883	29,776	16,838
Linlithgow	120	17,844	19,451	10,703	11,982	22,685	27.1	189.0	1,224	1,817	1,924
Nairn	195	8,257	8,251	4,082	4,924	9,006	9.0	46.2	799	429	903
Orkney and Zetland	1280	46,824	46,153	24,070	29,054	53,124	13.4	41.5	6,604	1,524	2,355
Peebles	319	8,735	9,935	4,973	5,073	10,046	15.0	31.5	837	651	474
Perth	2588	126,366	135,093	66,033	73,017	139,050	10.0	53.7	7,774	12,523	10,673
Renfrew	225	78,056	92,596	51,178	60,997	112,175	43.7	498.5	2,725	15,780	5,472
Ross and Cromarty	2885	55,343	60,853	32,324	36,504	68,828	24.5	24.0	7,947	3,356	3,203
Roxburgh	715	33,682	37,230	19,408	21,484	40,892	21.4	57.2	3,613	2,822	2,204
Selkirk	263	5,070	5,889	3,205	3,432	6,637	30.9	25.2	421	409	542
Stirling	489	50,825	58,174	31,718	33,658	65,376	28.6	133.7	2,600	6,641	4,492
Sutherland	1754	23,117	23,629	11,088	12,752	23,840	3.1	13.6	3,362	642	818
Wigton	451½	22,918	26,891	15,837	17,403	33,240	45.0	73.6	3,525	2,089	1,160
Totals	29,600	1,599,068	1,805,688	983,552	1,109,904	2,093,456	30.9	70.7	130,699	190,264	126,997

From this Table it appears that, with the exception of Orkney and the small county of Nairn, there was an increase in all the counties of Scotland between 1801 and 1811; and that in every one of them the population of 1821 is greater than that of 1801; so far is it from being true that the Highlands of Scotland, as has often been alleged, are in the course of being depopulated. The greatest increase is in the manufacturing county of Lanark and in the county of Edinburgh; but several counties, which are wholly or chiefly agricultural, have also increased considerably in these twenty years. The rate of increase for the whole period is very nearly 31 *per cent.* on the population of 1801. From 1801 to 1811, the rate is nearly 13 *per cent.;* and from 1811 to 1821 it is $15\frac{6}{7}$ *per cent.* If the population should go on increasing at the last rate, the period of doubling would be little more than 47 years. The average population, *per* square mile, is 70.7; the lowest being that of Sutherland, which is only at the rate of 3.1 *per* square mile, and the highest that of Edinburgh, which is 541.

Births, Marriages, and Deaths.

From the want of correct registers, the proportions of births, marriages, and deaths, cannot be accurately stated; but in the absence of these, we give the following general results for the city and suburbs of Glasgow, of which the population, in 1822, was 147,043:

The number of Births, including still-born,.....5,624
Marriages, ...1,470
Burials, ...3,690
Births to one marriage, ...3·815
——— to one burial, ...1·524
Burials to one marriage, ...2·510
One birth to persons, ...26·146
One marriage to persons, ...100·029
One burial to persons,.........39·849
(See Cleland's *Statistical Tables.*)

Town Population.

The population of the principal towns, at the periods of the three enumerations, was as follows. Those to which the letter *B* is added are royal burghs:

Scotland.

Towns.	1801.	1811.	1821.
Edinburgh, *B*	82,560	102,987	138,235
Glasgow, *B*	77,385	100,749	147,043
Paisley	31,179	36,722	47,003
Aberdeen (city and district), *B*	35,412	44,211	55,094
Dundee, *B*	26,084	29,616	30,575
Greenock	17,458	19,042	22,088
Perth, *B*	14,878	16,948	19,068
Dunfermline, *B*	9,980	11,649	13,681
Kilmarnock	8,079	10,148	12,769
Inverness, *B*	8,732	10,757	12,264
Falkirk	8,838	9,929	11,536
Dumfries, *B*	7,288	9,262	11,052
Montrose, *B*	7,974	8,955	10,338
Campbellton, *B*	7,093	7,807	9,016
Ayr, *B*	5,492	6,291	7,455
Stirling, *B*	5,256	5,820	7,113
Irvine, *B*	4,584	5,750	7,007
Port-Glasgow	3,865	5,116	5,262
St Andrew's, *B*	4,203	4,311	4,899
Rutherglen, *B*	2,437	3,529	4,640

It appears from the *Report* made to the General Assembly in 1818, that there were of

Blind 1100
Deaf and Dumb 784
Insane....................4650

6534, being in the proportion of 1 to 320 of the population of 1821; but for the insane, the returns were not complete, and the numbers of the blind and deaf and dumb are given partly on supposition.

IX.—Revenue.

Revenue.

The revenue of Scotland, at the Union, was as follows:

Crown rents	L. 5,500	0	0
Feudal casualties	3,000	0	0
Carry forward,	L. 8,500	0	0

Scotland.

Brought forward,	L. 8,500	0	0
The customs	30,000	0	0
The excise	33,500	0	0
The post-office	1,194	0	0
Coinage impositions	1,500	0	0
The land-tax	36,000	0	0
Total	L. 110,694	0	0

For the year ending 5th January 1804, the amount is thus stated (Sinclair's *History of the Revenue*):

Customs	L. 729,694	0	0
The excise, including the salt-tax, but exclusive of the annual duties on tobacco and malt	1,281,856	0	0
Tobacco and malt, annual	112,467	0	0
Stamps	194,275	0	0
The post-office	117,321	0	0
Land and assessed taxes	215,839	0	0
The 6d. *per* pound on pensions, salaries, &c.	2,666	0	0
The 1s. on ditto	3,860	0	0
	L. 2,657,978	0	0

Of which there was paid for

Collection	L. 230,721	0	0			
Bounties, &c.	355,816	0	0			
Expences of civil government of Scotland	137,165	0	0			
Deduct				723,702	0	0
Remains				L. 1,934,276	0	0

Of which there was remitted to the Exchequer of Great Britain L. 1,932,397.

In 1813, the nett revenue was L. 4,155,599, including the property-tax, the gross receipt of which was L. 966,790.

The property-tax having been repealed, and other taxes reduced, the gross and nett revenue, and charges of management for the year ending 5th January 1822, were as follows:

	Gross Revenue accrued within the Year.			Nett Revenue accrued within the Year.			Charges of Management.			Rate *per cent.* of Expence Collecting. The Gross Revenue.			The Nett Revenue.		
	L.	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*
Customs	759,796	7	$9\frac{1}{2}$	405,156	2	11	148,042	5	5	19	9	8	36	10	9
Excise	2,408,972	0	$2\frac{3}{4}$	2,035,401	11	7	169,403	18	$11\frac{1}{2}$	7	0	8	8	6	5
Stamps	480,274	5	$1\frac{1}{2}$	438,172	5	$7\frac{1}{2}$	32,542	11	3	6	15	6	7	8	6
Land and assessed taxes	470,311	2	$5\frac{1}{2}$	432,223	13	$6\frac{1}{2}$	38,087	8	11	8	2	0	8	16	3
Post-office	168,250	10	7	120,855	6	$0\frac{1}{2}$	47,395	4	$6\frac{1}{2}$	28	3	5	39	4	4
Duty on pensions	4,963	2	11	4,833	2	11	130	0	0	2	12	5	2	13	10
Totals	4,292,567	9	$1\frac{1}{4}$	3,436,642	2	$7\frac{1}{2}$	435.601	9	1	10	2	11	12	13	6

Of the two great branches of customs and excise, Scotland pays considerably more than appears in this abstract; for several important articles, tea for instance, pay the duties in England, and are, therefore, included in the English accounts, though partly consumed in Scotland, to which they are carried duty free.

The following Abstract, made from an account

presented to the House of Commons in May 1823, shows the exciseable articles paying duty in the years ending 5th July 1792 and 1822 respectively, and the amount of duty on each:

Articles.	1792.			1822.		
Auctions	L. 4,700	8	$8\frac{3}{4}$	L. 13,645	12	$6\frac{1}{2}$
Beer and ale	55,078	8	2	87,217	9	$9\frac{1}{2}$
Bricks and tiles	3,283	13	$3\frac{1}{2}$	6,348	16	$4\frac{1}{4}$
Candles	16,804	7	$10\frac{1}{2}$	19,704	2	$3\frac{1}{2}$
Coaches	99	0	0	....		
Cocoa nuts and coffee	443	17	$11\frac{3}{4}$	16,785	3	6
Cyder and perry	....			28	8	$1\frac{1}{4}$
Glass	24,719	9	$1\frac{1}{2}$	132,770	13	7
Hides and skins	19,618	13	$7\frac{1}{4}$	51,045	6	7
Licences	10,813	3	2	90,581	8	5
Malt	74,960	12	$0\frac{1}{2}$	199,695	3	9
Paper	5,744	18	2	63,688	19	3
Pepper	....			305	7	6
Printed goods	78,002	0	4	246,278	7	$5\frac{1}{2}$
Salt	....			106,992	16	8
Soap	43,969	8	$4\frac{1}{4}$	122,306	6	$8\frac{1}{4}$
Starch	9,749	17	$3\frac{1}{2}$	5,325	12	3
Spirits (foreign)	56,520	8	$1\frac{1}{4}$	124,112	10	1
—— (British)	52,470	5	2	740,709	14	$5\frac{3}{4}$
Stone bottles	....			9	4	$11\frac{1}{2}$
Sweets	....			111	1	4
Tea	....			49	4	2
Tobacco and snuff	31,774	8	$5\frac{1}{4}$	301,428	2	$7\frac{3}{4}$
Vinegar	....			753	17	0
Wine	30,990	9	$6\frac{1}{2}$	68,716	2	$0\frac{1}{2}$
Totals	L. 519,743	9	$4\frac{1}{2}$	L. 2,398,609	11	$5\frac{1}{4}$

Civil Establishment.

The expence of the Civil Establishment of Scotland, for the year ending 5th January 1823, was L. 137,635, 17s. $7\frac{5}{12}$d. This sum, to the amount of L. 114,250, 11s. $10\frac{5}{12}$d., is composed of the salaries of the Crown Officers, of the Judges and Officers of the several courts in Edinburgh, and of the Sheriffs'-depute and substitute of the counties.

X.—Representation in Parliament.

Of the Peers.

The Peerage of Scotland is represented in the House of Lords by 16 members of their body; and the Counties have 30 and the Royal Burghs 15 members in the House of Commons.

At the Union, the number of Scotch Peers was 159; of whom, in 1812, 77 were extinct or dormant, or their titles merged in, or united to others, or forfeited; and of the remaining 82, 23 were British Peers and two Roman Catholics. The Peers who were qualified to vote at the election in that year were 74, but the number who actually voted was only 52.

Of the Counties.

Each county sends one member to the House of Commons, with the exception of Bute and Caithness, Clackmannan and Kinross, Cromarty and Nairn, which have only three members: each of these pairs choosing a member alternately.

Of the Burghs.

The burghs, 66 in all (see Scotland in the *Encyclopædia*), with the exception of Edinburgh, which sends a member by itself, are classed together, not fewer than four, nor more than five; every class or district choosing one member by means of delegates sent from each of its burghs. These delegates are chosen by the magistrates and town-councils, who, with one or two exceptions, are themselves nominated by their predecessors in office, and not by the burgesses. The number of electors in each burgh varies with its particular Constitution, but may be averaged at 20, making 1320 in all. The population of the *royalties* of these burghs cannot be less than 456,000. (See Cleland's *Statistical Tables.*)

The population in 1821 being 2,093,456, and the number of representatives in Parliament 45, there is thus a representative for every 46,521 persons over all Scotland; and taking the burghs by themselves, one for every 30,400 persons residing within the *royalties*, exclusive of the inhabitants of the suburbs and dependencies; which, in the case of Edinburgh and Glasgow, are more numerous than those of the burghs themselves.

Again, as to the proportion of the inhabitants who enjoy the elective franchise, the number of the freeholders (at Michaelmas 1822) being, as already stated, ...2987
and the voters in the royal burghs 1320

the total number of voters is.........4307; or at the rate of one in every 486 of the population. Finally, the 30 members for the counties have each, at an average, $99\frac{1}{2}$ constituents, and the 15 members for the burghs 88; and taking all Scotland, the electors are to the members as about $95\frac{2}{3}$ to 1.

Several large or considerable towns, such as Pais-

ley, Greenock, Kilmarnock, and Falkirk (see the preceding Population Tables), not being burghs, have no share in the elections; while Queensferry, Fortrose, New Galloway, and Anstruther, having each only from 500 to 1000 inhabitants, and other 16, less than 2000 each, have near one-third of the political influence of the Scottish burghs. The county of Fife, which in this respect may be called the Cornwall of Scotland, has 13 of the 66 burghs; of which nine are so inconsiderable as scarcely to deserve the name of villages.

The inadequacy, inconsistency, and inequality of this system of representation is abundantly obvious; but the discussion of these points does not belong to this place.

XI.—Judicial Establishments.

Sect. 1.—*Civil Jurisdictions.*

1. *Justices of the Peace.* These are magistrates appointed by royal commission, within the several counties of Scotland, chiefly for the preservation of the public peace, but with a right also of exercising a limited jurisdiction in other respects, derived partly from statute, and partly resting on consuetude. No particular qnalification in point of rank, money, or property, is necessary here, as in England, to entitle a person to act as a Justice. The office is gratuitous, and is held during the pleasure of his Majesty.

The first introduction of Justices was above two centuries ago (1587, c. 82, 1609, c. 7), and their powers and duties have, from time to time, been regulated since, by various acts, both of the Scots and British Legislatures.

They are competent in questions of servants' wages, of aliment to natural children, of straighting marches and erecting fences between adjacent properties, &c. They issue warrants of *meditatio fugæ* against debtors intending to leave Scotland with a view of defrauding their creditors; and imprison them until they find caution *de judicio sisti.* They have ample powers in regulating highways, bridges, and ferries, and in determining questions concerning them. They judge in a numerous and important class of questions with regard to the revenue; particularly the Excise and Customs. They formerly had power to fix prices of work for artificers, labourers, and craftsmen, and to compel the service of these classes at the stated rates; but the old statutes authorizing this abuse are now repealed (*53d Geo. III. c.* 40).

The most important branch, however, of their civil jurisdiction, and certainly the most extensively useful to the public, is of modern date; viz. that which is vested under the Small Debt acts. Prior to these, there had existed in the city of Edinburgh, and it is believed in some other places, an ancient consuetudinary jurisdiction; under which the magistrates decided, in a summary way, questions of debt not exceeding L. 40 Scots. By *35th Geo. III. c.* 123, the experiment was tried of extending such a jurisdiction over Scotland, by authorizing any two or more justices, within their respective counties, to hold courts, and try all causes for recovery of debts not exceeding the same limited amount; and this being eminently successful, the system was improved and rendered perpetual by *39th and 40th Geo. III. c.* 46, which farther extended the amount of debt competent to be sued, to any sum not exceeding L.5 Sterling.

In the period from 1st October 1795 to 1st June 1800, there were decided in the small debt court of Edinburgh 13,968 cases, making an annual average of 2991; and from 1st June 1800 to 1st October 1820, 96,979 cases, or an annual average of 4767. The maximum debt competent to be sued, during the first period, was L.3, 6s. 8d. and the total value of the cases decided L.16,865, 6s. 1½d. During the second period L.5 was the maximum, and the total value of cases L.191,991, 16s. 8½d. In other districts the results were correspondent. In Glasgow, the number of decided cases averaged annually 5200; in Paisley, 1279. In some districts, courts are held weekly; in others once a fortnight, and in few, it is believed, seldomer than once a month. The fees of every step of procedure are regulated by the statute; and so moderate are they, that where the defender resides on the spot, and where no examination of witnesses, nor oath of party is required, an extracted decree may be obtained, if in absence of the defender, for 2s. 5d., and if he appear for 2s. 11d. Arrestment may be used on it for 6d. more; the defender's goods may be poinded and sold for 4s.; and his person may be lodged in jail for 3s. Expence is farther prevented by the absence of all written pleadings, and by the salutary provision that the parties shall conduct their cases in person.

The proceedings of the Justices in these small debt courts, unless, indeed, they have exercised jurisdiction in matters to which they are incompetent, are subject neither to "advocation, nor to any suspension, appeal, or other stay of execution;" but they may be challenged within a year from their date, by action of reduction, "on the ground of alleged iniquity, or oppression;" the pursuer being bound to give surety "for payment of such expences as may be awarded against him." (39th and 40th Geo. III. c. 46, § 13.)

In most other branches of their civil jurisdiction, the proceedings of Justices are subject to the usual processes of review in the Court of Session, or Circuit Courts of Justiciary. The Justices have no power of reviewing their own judgments; except in as far as an appeal generally lies to the Quarter Sessions from the judgments of the ordinary sessions. The Quarter Sessions are the stated quarterly meetings of the Justices of a whole county, which are appointed to be held on the first Tuesdays of March, May, and August, and the last Tuesday of October: or regular adjournments of these meetings. The ordinary sessions are the subordinate meetings held as occasion requires for the dispatch of business.

2. *Burgh Courts.* These may be considered as existing, 1*st*, In royal burghs; or 2*d*, In burghs of barony or regality.

(1.) In most royal burghs, there are both a *Bailie Court* and *Dean of Guild Court*; in others only the former, which, in that case, exercises in addition to its own all the functions peculiar to the latter.

The civil jurisdiction of the Bailie Court is as extensive within the limits of the burgh as that of the Sheriff in his county. It comprehends all questions arising out of *personal* contract, bond, or obligation, claims of debt to any amount, actions of damages, &c.; likewise all actions as to *real* property, which are merely of a possessory nature, and do not involve the question of radical title.

The jurisdiction of the *Dean of Guild Court* was formerly more extensive than now, comprehending "all actions, and matters concerning merchants,—betwixt merchant and merchant,—and betwixt merchant and mariner." (1593, c. 184.) The maritime part of this jurisdiction was taken away by 1681, c. 16, and vested exclusively in the Court of Admiralty: Neither have the Guild courts of a long time exercised the powers conferred on them in causes between merchant and merchant. (*Ersk.* 1. 4. 24.) Their chief province now is "to take care that buildings within burgh be agreeable to law, neither encroaching on private property, nor on the public streets or passages; and that houses in danger of falling be thrown down." (*Ibid.*)

Within the limits of the burgh, the jurisdiction of the Dean of Guild is exclusive; the Bailies again exercise a jurisdiction, for the most part cumulative with that of the Sheriff. The proceedings in both courts are conducted in writing, by practitioners admitted under authority of the judge; and proofs, when necessary, are taken by commission, the clerk of court, or some still more subordinate person, being usually the commissioner. The judgments pronounced may, in the first instance, be submitted to reconsideration of the inferior court by petition; ultimately they may be brought before the Court of Session, or Circuit Court of Justiciary, by the usual processes of review.

From the constitution of these courts, the judicial functions can scarcely be said to be performed by the nominal judge; who, in few cases, has either experience, knowledge, or education, for the discharge of such an important duty. He is chosen for other purposes, deriving his authority from an annual election under the constitution peculiar to his burgh. The active and real discharge of the judicial office it has been found necessary to devolve upon the clerk of court, or other assessor appointed by the Magistrates and Council.

(2.) The judicial business in the courts of *Burghs of Barony* and *Regality* has in like manner been devolved upon assessors; the election of Magistrates being conducted there in a way preeisely similar to what prevails in the royal burghs.

Their jurisdiction was originally commensurate and cumulative with that of the Baron or Lord of Regality, their superior; and embraced all questions of debt or personal contract, with most of the possessory actions, &c., but subject to review in the same way as the similar classes of actions in the royal burghs. In those burghs "which are independent of the Lord of Regality or Baron," this jurisdiction still remains entire, notwithstanding the judicial powers of the latter, along with every other heritable jurisdiction, were almost entirely annihilated by 20th Geo. II. c. 43.; commonly called the Jurisdiction Act. A similar reservation has been held to extend to such burghs of regality or barony as, though dependent, are dependent upon royal burghs. (*Fac. Col. Dowie*, May 30, 1817.) Since the Jurisdiction Act, his Majesty has been empowered to erect free and independent Burghs of Barony, on those parts of the sea coast where the fisheries are carried on (35th Geo. III. c. 122); but the Magistrates of such burghs are only to exercise the powers of Justices of the Peace, cumulatively with the Justices of the county. (*Ibid.*)

3. *Baron and Regality Courts.* Before the Jurisdiction Act, every lord of regality, and every proprietor of lands erected by the Crown *in liberam baroniam*, had an extensive jurisdiction, both civil and criminal; and "a baron, where he sold part of his barony lands to be holden of himself, was even understood to communicate to the purchaser a certain degree of jurisdiction over that part of the barony which he had sold." (Ersk. 1, 4, 27.) By that act, however, the civil jurisdiction of the baron, &c. was expressly taken away, except in actions where the debt or damages should not exceed 40s. Sterling, or in those brought for recovering from his own vassals and tenants the feu-duties and rents of his lands, and the multures or services prestable to his mills (*20th Geo. II. c.* 43)—an exception which has very seldom been taken advantage of.

4. *Sheriff and Stewart Courts.* The office of Sheriff is of such antiquity, that no distinct trace remains either of its first institution, or of the amount of jurisdiction originally conferred with it.

The present form of the Court was introduced by the same statute which abolished heritable jurisdictions. The office of Principal or High Sheriff is no longer a judicial one (*20th Geo. II. c.* 43), but is granted solely for purposes of the executive government, and generally in connection with the office of Lord Lieutenant of the county. The judicial character is exclusively vested in the Sheriff-depute, who holds his commission directly from the Crown, and is in every respect independent of the Principal or High Sheriff, where such officer exists.

The office of Stewart has undergone similar modifications: and the distinction between the offices of Sheriff and Stewart is now merely nominal. Both are now judges of precisely the same class, having the same sort of duties to perform in their respective territories, and invested with the same powers, and the same extent of jurisdiction. By the Jurisdiction Act, "One sheriff-depute, or stewart-depute, is to be appointed by the King in every shire or stewartry not dissolved; who is to be an advocate of three years standing, and who is declared incapable to act as an advocate in any cause that shall be brought from his county. These deputies are authorized to name each a substitute, or substitutes, either over the whole shire, or within such a particular district of it as shall be mentioned in the substitution; and they may not only hold stated courts at their head burghs, but itinerant ones, when and where they please, or shall be directed by the King, on previous notice to be published at the several churches, within the district where the court is to be held." (*Ersk.* 1, 4, 11.) They hold their offices *ad vitam aut culpam*.

The sheriff or stewart exercises civil jurisdiction "in all personal actions upon contract, bond, or obligation, to the greatest extent, whether the suit be brought against the debtor himself or his representatives; in actions of rent and of forthcoming; in poindings of the ground; and even in adjudication of lands, when it proceeds on the renunciation of the apparent heir; in all possessory actions, as removings, ejections, spuilzies, &c.; in all brieves issuing from Chancery, as of inquest, terce, division, tutor, &c., and generally in all civil matters which are not by special law or custom appropriated to other courts." (*Ersk.* 1. 4. 3.) He judges also in questions of mutual inclosures, straighting of marches, runrig, &c. (1669, c. 17, &c.) By a recent statute (*4th Geo. IV. c.* 97), abolishing the inferior commissariats, he is invested with the office, powers, and jurisdiction of commissary. He has besides many important ministerial duties to perform.

The forms of procedure in the Sheriff-Court are much the same as in those of the Royal Burghs; and their judgments are liable to review in the same manner. As, however, in the Sheriff-Courts, it is the substitute who, in the first instance, generally decides, and as an appeal lies from his judgment to the sheriff-depute, an opportunity is in many cases given for a still more protracted litigation.

5. *Commissary Court.* This was originally an ecclesiastical court; but on the abolition of Episcopal jurisdiction in 1560, a new nomination of commissaries, one in every diocese, to act under the royal authority, was made by Queen Mary. Soon afterwards a supreme Commissary Court, consisting of four judges, who are now appointed *ad vitam aut culpam*, was established at Edinburgh; as already noticed, the inferior commissariats were abolished by a recent statute (*4th Geo. IV. c.* 97), and their jurisdiction conferred on the sheriffs.

The jurisdiction of the Edinburgh commissaries is exclusive in all strictly consistorial cases, viz. questions of marriage, divorce, separation, legitimacy, confirmation of persons dying abroad with estates in Scotland, &c. They have a cumulative jurisdiction with the sheriff and other civil courts, in actions of slander and defamation, aliment of wives against their husbands, applications for inspecting or sealing up the repositories of persons deceased, &c. Formerly the commissaries, both superior and inferior, had a jurisdiction in actions for the recovery of debts, not exceeding L.40 Scots; and, indeed, where their jurisdiction was prorogated there was no limit in point of amount; but this is now taken away, and all prorogation of their jurisdiction in questions of debt prohibited. (*4th Geo. IV. c.* 97.)

The Court of Session, as the King's great consistory (1609, c. 6), is vested with the power of reviewing all decrees pronounced by the commissaries, by advocation or reduction. The commissaries of Edinburgh used to have a similar power of review as to the jurisdictions of the inferior commissaries: but this had long fallen into disuse, and by the late statute, transferring the jurisdiction of the inferior commissaries to the sheriffs, it is declared that "all such proceedings shall be reviewable only by the Court of Session."

6. *Court of Admiralty.* The judicial powers exercised in ancient times by the Admiral of Scotland are not distinctly known. The offices of High Admiral and Vice-Admiral of Scotland are no longer judicial ones. That character now belongs only to the Judge of the High Court of Admiralty, who derives his commission *ad vitam aut culpam* immediately from the Crown, and who must be chosen from the list of practising advocates of at least three years standing. (*26th Geo. III. c.* 47.)

The jurisdiction of this court is chiefly regulated by the Scots statute 1681, c. 16. In civil causes, it is *exclusive* in strictly maritime questions, viz. in questions of charter-party, freight, salvage, wrecks, &c.; but merely *cumulative* with that of other civil courts in ordinary mercantile questions, viz. in actions on bills of exchange, mercantile contracts, policies of insurance, &c. In the latter class of cases, it is, with few exceptions, incompetent to raise any action in the Admiralty Court, where the subject in dispute, exclusive of expences, is of less value than L. 25 Sterling. (*1st and 2d Geo. IV. c.* 39.)

The Judge of the High Court of Admiralty may name inferior deputies, whose jurisdiction is confined within particular districts, and whose sentences are subject to the review of the High Court. The High Court may also review its own judgments, even after extracted decree, by suspension or reduction: a peculiar privilege, and usually appertaining to courts of supreme authority alone. This court is not, however, in a proper sense, Supreme; for the Court of Session is vested with a power of review as to all its proceedings, even in those questions where the jurisdiction of the Admiral is in the first instance exclusive.

The procedure in the Admiralty Court is substantially the same as has already been described in the rest. One important distinction is, that the Admiral has power, where matters of fact are to be proved, to remit cases for trial upon issues in the Jury Court. (*59th Geo. III. c.* 35.)

7. *Court of Session.* This Court is the supreme civil judicature of Scotland. It superseded the ancient courts of *The Session* and *Daily Council*, and was instituted in 1532, during the reign of James V. after the model of the Parliament at Paris. In its present shape, it consists of fifteen Ordinary Lords, including the Lord President and Lord Justice Clerk; who, till lately, acted as one great Court; but the increasing business of the country requiring an additional tribunal, it was divided into two Chambers, called the *First* and *Second Divisions*, each exercising independent, but cumulative and co-ordinate jurisdictions.

The Court of Session has an universal jurisdiction in civil matters. As a Court of Review, it has, with a few exceptions in special cases, the power of advocating, suspending, or reducing the decrees of all the inferior tribunals. As a court of the first instance, its jurisdiction is, in some causes, privative; *e. g.* in declarators of property in heritage, and other competitions of heritable rights; restitutions of minors; provings of the tenor; *cessio bonorum*; reductions of deeds, &c.; judicial sales; mer-

cantile sequestrations; complaints against burgh elections; proceedings of courts of freeholders, &c. In all others, its jurisdiction is cumulative with that of the inferior courts; excepting, 1*st,* That in causes under the value of L. 25 it is incompetent to raise actions before the Court of Session, in the first instance; and 2*d,* That in maritime and consistorial cases, &c. the Court of Session has no primary jurisdiction, and can proceed only by way of review.

The Court of Session is a court of Equity, as well as of Law, but in this respect its powers are loose and ill defined; its decisions in equity not being, as in England, regulated by any distinct or settled general principles. It exercises, also, what is called a *nobile officium;* an expression which, in ancient times, seems to have covered every exercise of power for which no more satisfactory source could be pointed out; and under which may be classed all those acts of interference which appear in the Books of Sederunt; sometimes fixing the price of victual in the city of Edinburgh; at others, regulating the sale of butcher-meat, or framing enactments against the "vending and retailing of bad twopenny ale" (*A. S. 8th July* 1725), &c.

The judicial proceedings in the Court of Session may be considered as they take place, 1*st,* In the Bill-Chamber; 2*d,* In the Outer-House; or 3*d,* In one or other of the Inner Divisions.

In Session time, the junior, or last appointed judge of the fifteen, has devolved on him the business of the *Bill-Chamber.* This chiefly consists in disposing of the preliminary stages of the process of review, where bills of suspension or advocation are presented against the decrees or proceedings of inferior courts; it embraces, also, questions of summary interdict against all illegal proceedings; suspension of diligence unduly put, or threatened to be put, in execution; liberation from prison, where execution has already taken place, &c. In time of vacation, the whole judges, with the exception of the Lord President and Justice Clerk, officiate in the Bill-Chamber by rotation. The judgments pronounced in the Bill-Chamber are subject to review in the Inner-House.

The business of the *Outer-House* is conducted by the five junior Lords of Session, including the Bill-Chamber judge, who has the particular department allotted to him of judging in actions of reduction, and in some other questions which are from time to time remitted from the Inner-House. The other four Lords Ordinary, as they are called (two belonging to either Division), officiate by rotation; they have separate rolls of causes, comprising, 1*st,* All actions brought in the first instance before the Court, except a few which are exclusively competent to the Inner-House; and, 2*d,* The class of cases which, passing through the Bill-Chamber, as above, have received the sanction of the judge there as deserving of further consideration. The proceedings in the Outer-House, like those in the Bill-Chamber, are subject to review in the respective Divisions of the Inner-House.

Each Chamber of the *Inner-House* consists of four Lords, three of whom are a quorum. The Lord President presides in the First Division, the Lord Justice Clerk in the Second. They are chiefly occupied in reviewing the judgments which have been pronounced by the Lords Ordinary in the Bill-Chamber or Outer-House. But they have also a primary and exclusive jurisdiction in the sequestration of landed estates; the appointment of judicial factors, curators *bonis* &c.; proceedings for redemption of the land-tax; complaints in election matters; petitions and summary complaints under the bankrupt statute, &c. In cases of great importance or difficulty, either Division of the Inner-House is empowered to take the opinions of the other judges; but these opinions when taken are not always regarded; and one case is reported where judgment was ultimately pronounced by the votes of three judges in one of the Divisions, though an unanimous opinion to the contrary had been given by no fewer than ten of the other judges, including the two Heads of the Court. (*Auld, Nov.* 12, 1819, *Fac. Col.*)

The extent of business before the Court may be judged of, from an interesting document lately drawn up by the Clerks of Session, under the directions of the Court. Two tables are there given;—one of "causes appearing in the printed rolls of the Outer-House;" from which the total number of such cases during the period from 1802 to 1822, inclusive, appears to be 50,970; giving an annual average of 2427:—another, of "original petitions, petitions and complaints, and other summary applications to the Inner-House;" from which the total number of such cases in the period from 1811 to 1821, inclusive, appears to be 5302, giving an annual average of 482.

The forms of procedure in the Court of Session it would require much space to explain. There, as in the inferior courts, all the more important pleadings are conducted in writing; and proofs taken by commission. In this latter respect, the power of remitting cases for trial upon issues in the Jury Court is a vast improvement, and may eventually draw after it, what is of great and essential consequence,—viz. a distinct separation of the matter of fact from considerations of law, in pronouncing judgment, even in those cases which are not submitted to a jury.

An appeal lies from the judgments of the Court of Session to the House of Lords. The disparity in the proportion of such appeals from Scotland, compared with those arising in the sister countries, is striking enough. Between 3d May 1813, and 14th March 1823, the appeals presented from Scotland alone were 426, while from England there were only 56, from Ireland 84, and from Wales 4. In 291 Scots appeals decided during the same period, only 145 were affirmed, while 62 were reversed, two altered, and 80 remitted for reconsideration. The increasing load of Scots appeals, combined with the circumstance of such a number of alterations and reversals, has lately given rise to much discussion; and a Parliamentary Commission is at this moment (October 1823) sitting, from whose investigation into the sources of the evil, the country is entitled to anticipate the most important and beneficial results.

8. *Teind Court.* After various temporary Commissions of Parliament, the first of which was ap-

pointed in 1617, c. 3, the Lords of Council and Session were at last created a perpetual "Commission for the Plantation of Kirks and Valuations of Teinds," by 1709, c. 9. This court, though consisting of the same individual judges, has always exercised a jurisdiction separate and distinct from that of the Court of Session; and when the latter was recently divided into two chambers, it was provided, that the former should in all respects continue untouched. The quorum of this court is nine: the same as that of the Court of Session before its division.

By the act 1707, the Teind Court was appointed to meet every Wednesday during the sitting of the Court of Session, but now it meets "once a fortnight only," viz. every alternate Wednesday. (*48th Geo. III. c.* 138.)

The extent of its jurisdiction is pretty fully set forth in the act 1707;—it has power "to determine in all valuations and sales of teinds; to grant augmentations of ministers' stipends; prorogations of tacks of teinds; to disjoin too large parishes; to erect and build new churches; to annex and dismember churches," &c.

9. *Jury Court.* This court is of very recent institution, having only been introduced so late as 1815. It is composed of one Chief Judge and two other judges, called "the Lords Commissioners of the Jury Court in Civil Causes;" but trials may proceed equally "in presence of one, or more than one, of the said three Commissioners." (*55th Geo. III. c.* 42.) The Commissioners must be either Lords of Session or Barons of Exchequer (*Ibid.*), with the exception of the Chief Commissioner, who may or may not hold such other judicial office, but must be qualified to be appointed a Lord of Session. (59th Geo. III. c. 35.) The court, as well as its forms of procedure, are framed very much on the English model; the jury also, as in that country, must be twelve in number, and their verdict unanimous.

As at present constituted, no action can *originate* before this court. It derives its jurisdiction by virtue of *Remits* either from the Court of Session, the Court of Admiralty, or the House of Peers, as the court of last resort. "In all processes raised in the Outer-House of the Court of Session, by ordinary action or otherwise, on account of injuries to the person, whether real or verbal, as assault or battery, libel or defamation; or on account of any injury to moveables, or to lands where the Title is not in question; or on account of breach of promise of marriage, seduction, or adultery; or any action founded on delinquency of any kind, where the conclusion shall be for damages or expences only" (*59th Geo. III. c.* 35), the Order for Remit after the lodging of defences is (unless a question of law or relevancy arises) peremptory. In other cases, "where matters of fact are to be proved," the Lord Ordinary in the Outer-House, or either of the Inner Chambers of the Court, the Judge of the High Court of Admiralty, and the House of Lords, judging on appeal, may or may not remit, as it shall seem expedient. (*Ibid.*) In all cases where such remits are made, it is declared incompetent to bring under review in any shape any interlocutor or judgment ordering a trial by jury.

The Jury Court has its *terms* and *sittings* like the English courts. The judges also travel *circuits* twice a year, about the same periods as the Lords of Justiciary.

10. *Circuit Courts of Justiciary.* The constitution of these courts will be explained below. The only thing to be noticed in regard to them here is, that they have a civil jurisdiction conferred on them by statute (*20th Geo. II. c.* 43; *54th Geo. III. c.* 67); whereby they judge, by way of appeal, from the sentences of inferior courts, in all cases not exceeding L. 25 in value, exclusive of the expences of litigation. The decision of the Circuit Judges in these cases is final; but in questions of difficulty they may certify the cause to the Court of Session.

11. *Court of Exchequer.* This is the King's Revenue court. The old Scots Court of Exchequer was superseded at the Union by the establishment of the present, which consists of a Chief Baron, and four (or rather, as the court is at this moment constituted, of three) Puisne Barons, who must be either Serjeants at law, or English Barristers, or Scots Advocates of four years' standing.

The judges of this Court have "a peculiar jurisdiction as to all duties of custom and excise, and other revenues pertaining either to the King or Prince of Scotland, and as to all honours and estates, real and personal, forfeitures and penalties of what nature soever, arising to the Crown within Scotland; and as to all questions relating to the said matters, which they are authorized to determine either in law or equity, by the same forms that have been used in the English Exchequer." (*Ersk.* 1. 3. 31.) By a late statute, this Court has also jurisdiction in questions as to the administration of what is called the *common good* of Royal burghs, at the instance of Burgesses against their Magistrates. (*3d Geo. IV. c.* 91.)

SECT. 2.—*Criminal Jurisdictions.*

Most of the Courts enumerated above as exercising civil, have also a certain jurisdiction in criminal matters.

1. *Justices of the Peace,* by the terms of their commission, &c. would seem here, as in England, to have power to judge even of the highest crimes; but in practice (perhaps from the circumstance of their never using juries), their jurisdiction is limited to the trial of petty delinquencies, *e. g.* all petty crimes tending to the disturbance of public tranquillity, petty acts of theft or pickery, &c. They are entitled to punish by fine or imprisonment, and perhaps also by banishment from the county, though this last seldom takes place, unless on the petition of, or consent of the party. Though the Justices, however, are not competent to the *trial* of the higher offences, they have full power, and it is a chief part of their duty, to take all necessary steps for securing the offenders, and making the proper investigations preparatory to trial: *e. g.* they lead precognitions as to all circumstances connected with the offence, grant warrant for apprehending the delinquent, for imprisoning him for examination, or trial, &c.; they issue warrants of search also as to stolen goods, &c.; and having thus so far brought the case into shape, they report their proceedings to the Crown officers,

with whom it lies to proceed or not before the competent court.

2. *Burgh Courts*, as to their powers in all those steps *preparatory* to trial of the graver offences, are on the same footing with the Justices;—but their own peculiar jurisdiction in the *trial* of criminal cases is somewhat more extensive. They are competent in *all* the lesser offences, where trial by jury is not required. Where the burgh grant carries an express right of Sheriffship, as is the case in Edinburgh, Stirling, Perth, &c. their jurisdiction within the bounds of the Royalty is co-extensive and cumulative with that of the Sheriff.

3. *Barony and Regality Courts*, since the Jurisdiction Act, have no criminal jurisdiction but in assaults, batteries, and smaller offences, which may be punished, either by a fine not exceeding 20s. Sterling, or by setting the delinquent in the stocks in the day time not exceeding three hours.

4. *Sheriffs* are competent to the trial of all crimes and offences, except treason, and the four pleas of the Crown, robbery, rape, murder, and wilful fire-raising:—in the lower classes of cases without, in the higher and more important with, the aid of a jury. Sheriffs cannot punish by transportation beyond seas, nor even by simple banishment from Scotland; but they may convict capitally; and sentence of death pronounced (28th January 1785) by the Sheriff of Forfar, in a case of house-breaking, seems actually to have been carried into execution. (2. *Hume*, 57 *and* 64.) In the preparatory steps towards trial of offences in the Supreme Court of Justiciary, Sheriffs exercise the same powers as Justices of the Peace, &c.

5. *Court of Admiralty*. This Court, in the first instance, has "the *exclusive* cognizance of the crimes of piracy, mutiny on shipboard, plundering of wrecks, destruction of insured ships, and others which may with propriety be called *maritime* causes." But in such crimes as murder, theft, &c. which "offend not against the rules of navigation, its jurisdiction is not exclusive, though they should be committed on shipboard." (*Ersk. I.* 3, 35.) It is the nature of the crime, not the local boundary of its perpetration, which regulates the Admiral's jurisdiction as *exclusive*; it is, on the other hand, the occurrence of the offence within the local boundary which alone gives existence to his jurisdiction as *cumulative*. The Admiral may punish capitally; an instance of which, in a case of piracy, occurred so late as 1822.

6. *Court of Session*. This Court also has a certain criminal jurisdiction. It is "competent to the trial of deforcement and breach of arrestment (1581, c. 118); of contraventi on of lawburrows (1581, c. 117); of perjury and subornation of perjury, when these offences emerge in the course of business before themselves (1555, c. 47); of fraudulent bankruptcy (1696, c. 6); of wrongous imprisonment, usury, and clandestine marriage, to the effect of inflicting the pecuniary penalties of these several transgressions (1701, c. 6; 1597, c. 251; 1661, c. 34). By ancient custom they are judges also in cases of improbation and forgery,"—also, "in the trial of the lower species of falsehood, when committed or discovered in the course of their judicial proceedings," &c. (2. *Hume*, 68; *Ersk.* 1. 3, 21.) They are likewise, to a certain extent, competent to the review of the proceedings of inferior courts. The criminal jurisdiction of the Court of Session is, in all cases, exercised without a jury.

7. *Justiciary Court*. This is the supreme criminal tribunal of Scotland. As at present constituted, it consists (besides the Justice General, who, by his commission, is constant President of the Court, but seldom if ever takes part in the judicial business) of six Judges, including the Lord Justice Clerk, all of them being likewise Lords of Session, and three being a quorum. (23d Geo. III. c. 35.) Its judgments proceed on the verdict pronounced by the majority of a jury of fifteen.

The jurisdiction of this Court, as it is supreme in degree, is also universal in extent. It embraces the four pleas of the Crown, and even High Treason, though this last is generally tried by a special commission of Oyer and Terminer, appointed by the Crown. As a Court of Review, also, the proceedings of all inferior judicatures, including the Court of Admiralty, may, with a few trifling exceptions, be brought before this Court.

The principal seat of the Justiciary Court is at Edinburgh. But, for the better dispatch of business, the act 1672, c. 16, divided Scotland into three districts; and *Circuit Courts*, with the full powers of the whole Court, are now appointed to be holden each spring and autumn, by two of the Commissioners, at Ayr, Dumfries, and Jedburgh; by two at Stirling, Glasgow, and Inverary; and by two at Perth, Aberdeen, and Inverness. It is "lawful for one judge to proceed on business in absence of his colleague." (Ersk. 13, 26.) These Circuits have also a power to review, by way of appeal, all sentences of inferior courts, inferring "neither death nor demembration." (20th Geo. III. c. 43.)

No appeal lies from the judgments and sentences of the Court of Justiciary, either to the House of Lords or any other tribunal.

(A.)*

Situation, Boundaries, and Extent.

SELKIRKSHIRE, a county in Scotland, situated between 55° 21′ and 55° 42′ north latitude, and between 2° 48′ and 3° 20′ west longitude from Greenwich. It has Mid-Lothian, or the county of Edinburgh, on the north; Roxburghshire on the east and south-east; Dumfries-shire on the south;

* The last section, that, namely, on *Judicial Establishments*, was contributed by a Gentleman of the Bar, well qualified to execute it with accuracy. The preceding sections were written by the Gentleman whose Signature is annexed to the Article.—Ed.

Selkirkshire. and Peebles-shire, or Tweeddale, on the west. The line which separates it from these counties being on all sides, but the south, exceedingly irregular, its area has been computed very differently; but, according to the latest authorities, it appears to be about 269 square miles, or 172,160 English acres. It includes only two entire parishes, with five parish churches: but other seven parishes belong partly to this, and partly to the adjoining counties.

Surface. This is almost entirely a pastoral district, and in many respects bears a resemblance to the higher parts of the contiguous county of Roxburghshire. Like the latter county, its general declivity is towards the north-east and north, where all its streams discharge themselves into the Tweed; and the surface differs principally, in so far as some of the hills are more elevated, its streams smaller, and the valleys in which they flow still more contracted. Several of the hills are more than 2000 feet high; such as Windlestraw Law at the northern extremity, on the confines of Mid-Lothian, Blackhouse Heights, and Minchmoor on the borders of Peebles-shire, and Ettrick-penn on the south-west boundary. The lower hills are for the most part green, and afford good pasturage for sheep; but heath prevails on many of the higher grounds, especially towards the south-west. The lowest land is about 300 feet above the level of the sea, and the sites of many of the houses are from 600 to 1000 feet high and upwards.

Rivers. The rivers are the Tweed, which crosses the north side of the county in its course from Peebles-shire on the west to Roxburghshire on the east; the Gala, which, for some distance, forms the boundary with Roxburghshire on the north-east, and falls into the Tweed, from the north, a little below the village of Galashiels; the Cador, a beautiful stream, which also joins the Tweed from the north; the Ettrick and Yarrow, which have their sources on the confines of Dumfries-shire, and, flowing north-east, almost parallel to each other, join their streams above Selkirk, and afterwards, under the name of Ettrick, passing to the west of that town, and, for a short distance along the boundary with Roxburghshire, enter the Tweed, in which their name is lost, and which then becomes the boundary with that county. The Ale, which rises in the north-east, soon after passes into Roxburghshire, and also the Borthwick, which washes the north-eastern boundary. Next to the Tweed, the most considerable waters are the Ettrick and the Yarrow, which receive, in the first instance, nearly all the other streams that traverse this district. Both have been celebrated in song, and given their names to some plaintive melodies of great beauty and feeling. The scenery on the Yarrow is exceedingly romantic and delightful. Soon after its rise, it passes through two lakes, the Loch of the Lows, and St Mary's Loch; the latter, which is separated from the former only by a narrow neck of level ground, and is three miles long, having its banks partly covered with coppice-wood, is the finest piece of water in the south of Scotland. From thence the Yarrow flows for eight or nine miles, through sheep-walks, without wood or cultivation; but afterwards the sides of the lofty hills in its course are covered with wood to a considerable height, and its valley is embellished with a variety of bushes and wild flowers. Ettrick, the larger stream, has a wider and more cultivated valley, and a little before it receives the Yarrow, natural wood begins to appear on its banks. It afterwards flows for four miles through a rich tract, sheltered by plantations on the hills, till it loses its name in the Tweed. From this river the whole district has been sometimes called Ettrick Forest; but the name of Forest here, as elsewhere, has long since ceased to denote the existence of extensive woodlands, of which, whatever may have been the case formerly, there are now scarcely any traces here. Besides the two lakes we have mentioned, a great many smaller ones are scattered over the east and south-east quarters, of which the more considerable are Lochs Alemoor, the principal source of the Ale, and Oakermoor, noted for the vast quantity of marl which it contains.

Soil, &c. The soil of the arable land, which does not much exceed one-twentieth part of the whole, is light, dry, and easily cultivated; and produces oats, barley, or bear, turnips and potatoes; but very little wheat, for which the country is too elevated, and its climate in general too moist and rigorous. There is no coal, limestone, or sandstone, but a great deal of shell-marl in the lakes and mosses, which, when situated conveniently for the arable land, serves as a valuable manure. The rest of the county is almost exclusively occupied by sheep, which are now, for the most part, of the Cheviot breed, though not often pure, and scarcely, in any instance, equal to those of Roxburghshire. The heath or mountain race still keep their ground near the sources of the streams in the elevated districts on the south-west. There is but a small number of cattle, which are kept chiefly for their milk. The valued rent of the county is L. 80,307, 15s. 6d. Scots, and the real rent of the lands and houses in 1812 was L. 41,162, 10s. Sterling. In the same year the land-rent was divided among forty-four estates, of which nine had each a valuation exceeding L. 2000 Scots, twenty were below L. 2000 and above L. 500, and fifteen below L. 500; a division which indicates that most of the district belonged to a few individuals. Two-fifths of the whole are held under entail. The principal proprietors are the Duke of Buccleuch, the Earl of Traquair, Lords Elibank and Napier, and gentlemen of the names of Pringle, Lockhart, Elliot, Murray, and Scott. Valuation and Rental.

Towns. Selkirk, the county town, and a royal burgh, and the village of Galashiels, contain nearly all that part of the population that is not employed in husbandry; and both are small places. Selkirk is situated on a rising ground below the confluence of the Yarrow and Ettrick near the borders of Roxburghshire, and is a place of considerable antiquity. Galashiels, on the Gala, north from Tweed, also on the borders of the same county, has been long distinguished for its woollen manufacture, the most considerable of the kind in the south of Scotland; where all the various processes, from the sorting of the fleece to the finishing of the fabric, are conducted with much skill and success. For some time only coarse cloths were made, such as were formerly worn by farm servants, seldom worth more than 3s. the yard, and

popularly known by the name of *Galashiel greys;* but within these few years some very fine broad cloths have been produced, and a hall has been opened for the sale of their cloths, similar to those long established at the woollen manufactories of England. A considerable proportion of the wool of the county finds a market at Galashiels. An inkle work and some tanneries are the only other branches carried on for sale out of the county; so that its exports consist chiefly of raw produce, of which its sheep and wool are by far the most considerable articles.

Representation.

Selkirkshire, which has thirty-eight freeholders, sends one member to Parliament, and Selkirk, along with Peebles, Lanark, and Linlithgow, elect another for the Scottish burghs. Though it is a very thinly peopled district, containing, in 1811, only about twenty-two inhabitants to the square mile, yet poor rates have been long and universally established. The population, according to the census of 1801, was 5070; in 1811 it amounted to 5889; and in 1821 to 6637, of which 3205 were males, and 3432 females. The *families* employed in agriculture were 421, in all other occupations 409. The increase of population, from 1811 to 1821, was 748.

Population.

See the general works quoted under the former Scottish counties, and Douglas' *General View of the Agriculture of Selkirkshire.* (A.)

SHETLAND, New South, a large tract of uninhabited land, situate to the southward of Cape Horn, discovered in 1819 by Mr William Smith, the master of a British merchant Brig, and which, in some minds, revived the belief of a vast continent within the Antarctic Circle. Mr Smith gave to it the name of South Shetland, on account of its lying nearly in the same degree of south, as the Shetland Isles of north latitude. There is a full account of his observations in a letter written by Mr J. Miers, published in the *Edinburgh Philosophical Journal*, Vol. III. p. 367. Though he gave the appellation of *New* to the land in question, it rather appears, as we have observed in our article on the Polar Seas, that the first discovery of it was made so long ago as the year 1599, by a Dutch navigator of the name of Gherritz. We have also stated, in the same place, that this land appears to be an Island, and not part of a Continent. See p. 215 of this Volume.

Sicily.

SICILY. This island, a part of the kingdom of the Two Sicilies, has undergone few or no changes, either in its government, manners, religion, or productions, during the convulsions which, for near thirty years, have agitated every part of the continent of Europe. Upon the overthrow of the government of Murat in Naples, the royal family returned to that capital, quietly resumed the authority that had formerly been exercised, and Sicily ceased to be the seat of government. The tranquillity which followed was interrupted by the late revolution in Naples, the promoters of which resolved to force their own regimen on the unwilling Sicilians. The island was invaded by the troops of the revolutionists, and after some most bloody encounters, was compelled to submit to the dictation of the triumphant party. They were in their turn dispersed by the Austrians, and the ancient system in Sicily was speedily restored, to the high gratification of its inhabitants.

Commerce.

The commerce of this island consists in the export of the surplus of its raw productions; for its manufactures are inconsiderable, and by no means equal to the wants of the people. The chief exports are corn, nuts, hemp, flax, oil, wine, sulphur, fish, silk, and fruits; the whole amount of which does not commonly exceed 11,000,000 ducats, or about L. 240,000 Sterling. The imports are of nearly the same value.

Finances.

The revenues of the island, in the year 1820, amounted to 1,637,332 ounces, or about L. 200,000, and the expenditure to 1,665,355. The expences are restricted to 1,817,680 ounces; of which sum 150,000 ounces are applied to the discharge of that part of the public debt which bears no interest, and after that is liquidated, to form a sinking fund to extinguish those on which interest is payable: the amount of the latter is not known to the public.

Army and Navy.

The regular Sicilian army, including the different branches of horse, foot, and artillery, amounts to 10,000 men, besides which there is a militia force of 8000. The Sicilian navy is now united with that of the kingdom in general. The arrangements respecting the forces are at present (1823) undergoing revision, and therefore in a temporary state of confusion.

Divisions.

Sicily has been recently divided into seven Intendancies, instead of the three great provinces, which before formed its component parts. These Intendancies, and their population, and principal cities, are as follows:

Intendancies.	Population in 1817.	Capitals and their Population.	
Palermo	405,231	Palermo	180,000
Messina	236,784	Messina	44,650
Catania	289,406	Catania	45,081
Siragosa	192,710	Siragosa	13,850
Caltanisetta	155,225	Caltanisetta	15,627
Girgente	288,877	Girgente	14,882
Trapani	145,712	Trapani	24,330
	1,713,945		

The whole extent of the island is calculated to be 12,533 square miles.

See Vaughan's *Views of the present State of Sicily*, 1812. Thompson's *Sicily and its Inhabitants*, 1815. Smyth's *Sicily and its Islands*, 1823. (w. w.)

SINCAPORE, or Singapore, an island in the Straits of Malacca, situate at the extremity of the Peninsula of that name, upon which a British Settlement was formed in 1819, under the enlightened direction of Sir Thomas Stamford Raffles, the Lieutenant-Governor of Bencoolen. Of this island, upon which there is a town of the same name, nothing has

Sincapore. yet appeared, so far as we know, in the way of description, except some detached notices in periodical publications, particularly in the *Asiatic Journal*. We are thus unable to give any very distinct or detailed account, either of its situation, extent, or productions. In the interior, its surface is said to exhibit a succession of hills and dales, mostly covered with woods, and affording some fine prospects. The soil is fruitful; the water, a material circumstance, of good quality; the temperature remarkably cool for a tropical region; and the climate has hitherto proved extremely healthy.

The town of Sincapore exhibits yet all the appearances of an infant settlement, but it is rapidly extending, and a site for its enlargement is laid out upon a regular plan. It is built near the shore, and the mercantile part of it extends along an inlet of the sea, which penetrates into the interior, and is near 300 feet wide at its mouth; affording every facility for the landing and shipping of goods. The harbour is safe, easily approached, and well sheltered. Several mercantile houses of respectability are already established here; and there seems every reason to believe, that if maintained on the present footing of a Free Port, Sincapore will at no distant day become one of the greatest emporiums of the Eastern world. Its situation, in the centre, so to speak, of a vast Archipelago, in a strait through which the vessels of various countries are constantly passing, and within a few days sail of China, clearly points it out as well fitted to become the entrepot of an extensive commerce, equally beneficial to these countries and to Britain. There are several statements to this effect, in the Evidence annexed to the *Report of the Select Committee of the House of Lords relative to the Trade with India and China*, printed, by order of the House of Commons, in May 1821.

The establishment of a British settlement in Sincapore is said to have excited some feelings of jealousy in the older one of Penang, or Prince of Wales' Island; but the Evidence just referred to shows, that if such a feeling exists, it ought to be discouraged and disregarded; for it there appears that a settlement situate farther within the Archipelago than Penang was highly expedient, and that Sincapore presented the most eligible situation for founding such a settlement as was wanted. The rapidity of its progress affords, of itself, sufficient proof that the situation was well chosen. "The rapid rise of this important station," says its intelligent founder, in a letter written in 1820, annexed to the abovementioned *Report*, "is, perhaps, without a parallel. When I hoisted the British flag, the population scarcely amounted to 200 souls; in three months the number was not less than 3000; and it now exceeds 10,000, principally Chinese. No less than 173 sail of vessels of different descriptions, principally native, arrived and sailed in the course of the first two months; and it already has become a commercial port of importance."

The latest accounts seem to contain additional proofs of the growing importance of this settlement. We copy the annexed statement from the *Asiatic Journal* for September 1823. (No. 93, p. 245.)

Sincapore || Sligo.

The following is the amount of tonnage, &c. employed in 1822.

Exports.		Tons.
By ships........ . ... ..Tons	51,076	66,968
By native vessels	15,892	
Imports.		
By ships..	48,037	63,661
By native vessels	15,624	
Total tonnage		130,629

Number of vessels importing in 1822	1,593
Ditto exporting ditto.......	1,733
Total	3,326

Value of imports in 1822.		Drs.
By ships ....Dollars	2,597,975	3,610,206
By native vessels............	1,012,231	
Value of exports in 1822.		
By ships.....	2,044,871	3,172,332
By native vessels...........	1,127,461	
		6,782,538
Not included in official returns		1,713,634
Total amount of imports and exports....................Dollars		8,496,172

The settlement of Sincapore was early disturbed, not merely by the conflicting interests of other British establishments in the East, but by certain pretensions brought forward by the Dutch to the possession of the country, as a dependency of Malacca, over which they claimed sovereignty. The discussions which arose between the British Government and that of the Netherlands, upon this point, have for some time, it is understood, been allowed to rest; and if they should be resumed, it is not very likely that this country will agree to sacrifice an important establishment, to satisfy claims which seem to have no better foundation than the commercial jealousy of the claimants.

SLIGO, a county in the province of Connaught, in Ireland, bounded by the ocean on the north-west and north, by Leitrim and Roscommon on the east and south-east, and by Mayo on the south and west. It extends about 40 miles from north to south, and from east to west 38, and contains 727 English square miles, or 465,280 English acres. The town of Sligo, which is about 13 miles from its northern extremity, is situated in west longitude 8° 26′, and north latitude 54° 13′. The county is divided into six baronies and thirty-nine parishes.

Situation and Boundaries.

Extent.

Bogs, mountains, and waters, occupy more than a third of this district. The greater part of the waste land is found towards the north and west, though there are considerable tracts of the same description on the south; but except the range of the Ox and Foxford mountains, which begin on the

Surface.

Sligo. confines of Mayo on the south-west, and occupy a considerable part of the western division, the waste grounds are everywhere intermixed with such as are productive, and in some parts very fertile. The better part of the district lies to the south of the town of Sligo; a few miles from which, along its whole breadth, the country is in general rich and beautiful, containing several gentlemen's seats, and presenting views of great variety and interest. For about 140 square miles in this quarter, the soil is equally fitted for tillage or grazing. In other parts much of it is shallow and moorish, incumbent on a close stratum, here called *leaclea,* or grey flag, which, in its natural state, is unfavourable to vegetation, though it becomes friable on exposure to the atmosphere.

Minerals. Lead, iron, manganese, and copper, are known to exist in the mountains; of these iron only has ever been wrought, and that not for many years; and there is a variety of clays, some of them very fine, or fit for the pottery.

Waters. The principal fresh water lakes are Loughs Gill, Arrow or Arva, Talt, and Gara. The scenery around Lough Gill, which contains a number of wooded islands, is particularly striking. On Innismore, one of these islands, are the remains of a church and other ruins. On the north, the sea has formed several considerable inlets, particularly at the bays of Sligo and Killala, the former of which communicates with Lough Gill, near the town of Sligo. To the north of this bay is the small Island of Innismurry. This district has also a great number of streams; of which the most considerable are the Sligo, Bonnet, Owenmore, Arrow or Arva, Cooloney, Esky, and Moy; the last of which is for some miles the boundary between this county and Mayo. The Sligo, which is merely the outlet of Lough Gill, is navigable from the lake to the town of that name; and the Moy for six or seven miles from the sea. On the Sligo and the Moy there are considerable salmon fisheries; trout is plentiful in the lakes, particularly in the Talt and Gara, and on the coast there is abundance of white fish. Herrings have not much frequented it for many years, yet a few are still caught in summer.

Estates and Farms. Sligo contains estates of almost every size. A few are worth from L. 5000 to L. 9000 a year; yet a considerable proportion of the county is divided into small properties. The principal proprietors are absentees. Farms vary in size from three acres Irish to 500; the larger farms, however, are not held by individual tenants, but in partnership. The leases are for 31 years and three lives, and in some instances for 61 years and three lives, being, in general, longer here than in other parts of Ireland. Tillage farming is still in a very backward state. The plough is worked by three or four horses yoked abreast, directed by a man who walks backward before them. Oats, barley, and potatoes, are the principal crops. Of the two former, a great proportion is consumed in illicit distillation, which, within these few years, was carried on in almost every of the county. It was to the sale of the spirits that many of the small tenants looked as the means of paying their rents. In some parts, both cattle and sheep are kept in considerable numbers, and a great deal of butter is exported from the town of Sligo; but the land occupied in this way bears but a small proportion to the whole; to grow corn being the principal object. Limestone and limestone gravel, which are in abundance in most places, are in general use as manures; also marl, and on the coast seaweeds.

Manufactures. The manufactures for export are linen, salt, and kelp. There is a linen hall at Sligo, where a good deal of business is done in this line; and from this place, which is situated on the bay of that name, the cloth is sent in large quantities to the English market in a finished state; there being many bleaching-greens in the county. This being the only town of any extent, and having a harbour that admits vessels of 200 tons close to its quay, all its exports and imports centre here. Besides linen and butter, Sligo exports a great deal of corn. Its population, according to the author of the *Agricultural Report,* is about 10,000. The other places called towns, of which there are 21 in all, are inconsiderable hamlets at which fairs are held.

Condition of the Peasantry. The cabins, food, fuel, and clothing, of the lower classes seem to be as uncomfortable as in any of the Irish counties already described. About 20 years ago, the price of labour, near the town of Sligo, was about a shilling a day throughout the year. Cottiers who had a cabin, an acre of land, and grass for a cow, for L. 3 a year, got only 5d. or 6d. In 1815, the rate of common labour in the country parishes was only 10d., and 1s. 1d. in spring time and harvest. Beef and mutton were from 3d. to 5d. *per* pound; oatmeal 10s. to 12s., and potatoes 1s. to 1s. 4d. *per cwt.*

In 1790, the population of this county was about 60,000, and by the census of 1821, it was 127,879. According to Mr Wakefield, the Catholics are to the Protestants at least as 80 to 1. In one considerable landward parish, that of Kilmactige, there were, in 1815, 1200 Catholic and only 10 Protestant families. The Irish language is still very common, and in some places English is almost unknown. Within these few years, the London Hibernian Society has established several schools, which promise to effect a happy change among the lower classes, who seem to be very ignorant and superstitious, and of most irregular and improvident habits. Their marriages, which are generally contracted at an early age, and their christenings and funerals, are all conducted at a most unsuitable expence both of time and money. The numerous holidays of the Catholic Church, passed in sport or idleness rather than in religious observances, and their habit of attending fairs and markets without having any business at them, have also a very bad effect on the industry of the people; whose condition is still farther depressed by the payments that must be made to their clergy at baptisms, marriages, confessions, and on other occasions. Accordingly, while many of the men leave home in summer to find employment elsewhere, their wives and children set out at the same time and travel over the country as beggars till their return.

Representation. Sligo county sends two members to Parliament, and the town of Sligo, which has twelve self-elected burgesses, a third. Mr Wynne is patron of the

Somersetshire.

borough, and the political influence of the county is in possession of absentees.

See Mr Parlan's *Statistical Survey of the County of Sligo* (1802), and the general works quoted under the former Irish counties. (A.)

Boundaries and Extent.

SOMERSETSHIRE, a maritime county of England, lying in a crescent-like form on the Bristol Channel, to which its north-western side is turned. It is bounded to the north-east by Gloucestershire, on the east by Wiltshire, on the south by Dorsetshire and part of Devonshire, and on the west by the latter county. Its greatest length, from east to west, is 65 miles, and its greatest breadth, from north to south, 45 miles. Its boundary line has several considerable indentations. The whole area comprehends 1642 square statute miles, or 1,050,880 English acres; being in extent the seventh in the list of the English counties. The acreable value of the land, according to the late returns under the Property-tax, exceeded that of any other county except Leicestershire, being, including the tithes, L. 876 *per* square mile, or about 27s. *per* acre.

Divisions and Population.

The civil divisions of this county are denominated the eastern and the western. The eastern division contains twenty hundreds and seven liberties, and the western twenty-two hundreds. The whole country is in the diocese of Bath and Wells; and is ecclesiastically divided into three archdeaconries, under which are 13 deans, who superintend 482 parishes. There are within the county two cities (besides a part of Bristol), seven boroughs sending members to Parliament, and twenty-nine market towns. The population, by the returns under the census of 1821, was 355,314, of whom the males were 152,447, and the females 165,357. The increase since the census of 1801 had been at the rate of 17 *per cent.* The inhabited houses were 61,852, the uninhabited 1974, and those building 850. The number of *families* was 73,537, of whom 31,448 were chiefly employed in agriculture, 27,132 in trade, manufactures, or handicraft, and 14,957 not included in either of the preceding classes.

Face of the Country.

Few districts contain a greater variety of soil and situation than the county of Somerset. In the north-east corner, the range of the Mendip hills present a lofty tract of country, of late improved on the surface, but chiefly valuable for the coal and other mines beneath it. On the western side are the Quantock hills, an extensive and sterile range, and beyond them the elevated bleak plane called the Forest of Exmoor, the highest district in the western counties. One spot on this forest, called Dunkeny, is 1668 feet above the level of the sea, and from it a prospect over an extended and diversified country is displayed; terminating on one side in the Bristol, and on the other in the English Channel. These hilly, and somewhat barren portions of the county, bear, however, but a small proportion to the whole; and between them is to be seen the richest meadows and arable lands, whose value more than counterbalances the sterility of the hills. In the better parts of the county, it may rather be described as rich than beautiful. There is a deficiency of woods; the streams that run in the valleys are sluggish, and in summer nearly stagnant; but the extent of orchards, especially when in full bloom, produce a pleasing effect, and in some measure compensate for the want of woods.

Rivers and Canals.

The rivers of the county are the Avon, which enters it from Wiltshire, and becomes navigable at Bath, which city it nearly surrounds. It then passes, with many curvatures, to Bristol, and soon after is lost in the Severn. The Axe rises in the Mendip hills in two branches, one of which issues from a natural excavation, called Wookey Hole, resembling some of the Derbyshire caverns. Its course is short, and it empties itself through some marshes, below Axbridge, into the Bristol Channel. The Brue rises in Wiltshire, and also enters the Bristol Channel, being navigable not more than two miles from its mouth. The Parret rises at a village of the same name in Dorsetshire, becomes navigable at Langport, and in rainy seasons a few miles above that town. It is joined, at Boroughbridge, by the Thone or Tone, which proceeds from Taunton, and passing by Bridgewater, empties itself into the sea. The only navigable canal that has been completed is the Kennet and Avon, which unites together the two great rivers Thames and Severn. It commences near Bath, and soon enters Wiltshire. Other canals have been projected in different directions, but none of them have been prosecuted to completion; though on several of them large sums have been expended.

Cattle and Dairy.

As Somersetshire contains, on the borders of its rivers, large tracts of the richest meadow lands, the most valuable branch of its rural economy is the fattening of cattle and the management of the numerous dairies. The oxen, bred chiefly in the less fertile pastures of Devonshire, when grazed in this county, afford the best beef, and furnish, in great numbers, the markets of the metropolis, as well as those of Bristol and Bath, in their immediate vicinity. The produce of the dairy is of the best kind. The cheese of Cheddar has obtained great celebrity, but that made in many other parts, and frequently sold as Gloucester, is equal to any in the world. The butter in the southern division of the county is excellent, and much of it, collected in the vicinity of Crewkerne, is sent to the London cheesemongers, who supply it to their customers under the denomination of Dorsetshire butter.

Productions of the Soil.

The next agricultural product is cider, which forms almost the universal beverage of the working classes. It is a more pure and yet a stronger liquor than the cider either of Herefordshire or Devonshire; the consumption of it within the country is very large, and some is sent to distant parts. Nature has been so bountiful in furnishing spontaneous productions, that less attention is paid to those agricultural pursuits which depend on skill and industry in this than in many other districts. The abundance of natural grass is such, that the farmers do not find it necessary to grow a crop of clover, or other artificial grass, so uniformly between two corn crops as is necessary in other counties; nor is the practice of fallowing, or of introducing a rotation by commencing with turnips, much resorted to. Notwithstanding this, they grow good crops of corn, and in the hundred of Taunton Dean the wheat is of the very best quality. Barley is not cultivated very extensively, as the ge-

Somersetshire || Spain.

neral use of cider causes but little consumption of malt. The bear crops are in general very good. Oats are cultivated extensively, but scarcely equal the demands of the county, and the easy intercourse with Ireland readily supplies any deficiency when it occurs. The soil is well calculated for the growth of flax, and a large proportion of that used in the manufactures of the county is raised within it. It is not unusual to rent land for half a year whilst a crop of flax is grown; after which it is taken again by the regular occupant, who finds the flax to be an excellent preparative for wheat, from the careful weeding which was necessary to its success. The rich loamy soils bring to maturity the best elm timber. Goose feathers were formerly afforded in great abundance, but the draining and inclosing many of the richest marshy plains has rendered these capable of yielding more profit by other productions, and the quantity of feathers is much diminished of late years. The landed property of the county is much divided, no one proprietor or great family having such extensive possessions as to give a preponderant political influence. There is a great number of yeomen who share the lands, many of whom maintain the homely independence of the past generations.

Mineral Products.

The mineral products of this county are valuable. The hills of Mendip supply with coals their vicinity, the cities of Bath and Wells, and the towns of Frome and Shepton Mallet. The other parts of the county use the coals of Newport, which are brought by sea to Bridgewater. Lead, of a quality superior to that of Derbyshire, is raised in Mendip and on the Cheddar hills. Calamine is extensively produced, and supplies the brass manufacturers of Bristol. Copper is found near Stowey. Manganese, bole, and red ochre, are among the other products of Mendip.

Manufactures.

Nearly the whole of Somersetshire is a manufacturing country. Cloths of Spanish and Saxon wool are made extensively at Frome, Shepton Mallet, and their vicinity. Some woollen goods, of a middle quality, are produced at Ilminster, Chard, Taunton, and Wellington; and some of a coarser kind at Wevelscombe, Milvarton, Watchel, and other places. The linen goods are chiefly dowlas, tickens, and sailcloth; these are mostly made at Yeovil, Crewkerne, Montacute, and Martock. There are silk-mills at Bruton and Taunton. Gloves are extensively made at Yeovil. Of late, the wove-lace manufacturers from Nottingham have found secure asylums at Chard, from the insanity of the *Luddites*, and carry on there large manufactories. Near Wells are establishments for making fine paper; and in the vicinity of Bristol the glass-houses produce a large quantity of valuable wares.

Commerce.

The foreign commerce of Somersetshire passes chiefly through Bristol, which is the mart for such goods as are required in distant countries. Some of the woollen goods which are manufactured at Taunton and Wellington are shipped from Exeter. The far greater portion of the productions of the county are, however, destined to supply the demand for internal consumption. The cattle, butter, and cheese, are chiefly sent to London, and, in time of war, to Portsmouth and Plymouth. The linen and woollen goods are distributed through the western and Welsh counties, and, in general, are designed more for the home than for foreign markets.

Peerages.

The titles derived from this county are—Dukes of Somerset and Wellington; Marquises of Lansdowne and Bath; Earls of Bridgewater, Poulett, Bristol, and Ilchester; Barons Mendip and Glastonbury.

Members of Parliament.

The county returns two members to the House of Commons, and two from each of the following places: Bath, Wells, Taunton, Bridgewater, Ilchester, Minehead, and Milborn Port; besides two for the city of Bristol, which is partly in this county, and partly in Gloucestershire, but retains an independent jurisdiction as a county of itself.

Ilchester, from the elections being held there, and the gaol and county court, is usually considered the county town, although the assizes in the spring are held at Taunton, and in the summer at Wells and Bridgewater alternately.

The principal towns and their population are, Bath, 36,811; Taunton, 8534; Bridgewater, 6155; Wells, 5888; Shepton Mallet, 5021; Yeovil, 4655; Wellington, 4170; Frome, 12,411; Crewkerne, 3434; Bedminster, 7979; North Petherton, 3091; Wedmore, 3079.

See *Beauties of England and Wales*. Toulmin's *Taunton*. Bellingsley's *Agriculture of Somerset*, and Warner's *Bath*. (W. W.)

SOUTH WALES, New. See WALES, New South.

SPAIN.

The Article Spain, in the *Encyclopædia*, contains a full view of the history of that country from the earliest periods down to the expulsion of the armies of Buonaparte by Lord Wellington. It also contains some descriptive and statistical details, drawn chiefly from the work of M. Laborde. We shall here endeavour to supply what appears to us wanting in the article referred to, as well as to exhibit a view of the more recent history of this interesting and unfortunate country, and of its internal condition up to the date of its invasion by the army of Louis XVIII. in April 1823.

External Structure of the Spanish Peninsula.

I. Spain may be considered as composed of a series of mountain terraces, which, projecting successively their rugged edges towards the south, present a flight of gigantic steps from the Pyrenees to the Mediterranean.* From the Rock of Lisbon to Cape Creus, it stretches through a line of 216⅔ leagues,

* Wilson, *History of Mountains*, Vol. II. p. 113.

measuring 12° 18′ 40″ of longitude. The difference of latitude between Cape Ortegal, the most northern, and the islet adjoining Taríſa, the most southern point of Spain, is 7° 46′ 10″.

The chains of mountains which terminate and divide the great plains of the peninsula, are branches of the immense ridge that, from the most elevated part of Tartary, runs across Asia and Europe, penetrates into the south of France, by Switzerland, and, entering Spain in the direction of the valleys of Roncál and Bastán, separates Navarre from Guipúscoa; Biscay from A′lava; the highlands of Burgos from the plains of Old Castille; and Asturias from the kingdom of León; it then crosses Galicia, and dips into the ocean at the Capes Ortegal and Finisterre.*

The Pyrenees are lateral ramifications of this great trunk, which run east and west, on the eastern side of Spain, and take a south-west and north-west direction on the confines of Aragon and Navarre. The accumulated mass of these mountains presents, towards the peninsula, the convex side of a spherical segment, which, like a shield with its boss to the south, rounds its edges near the Atlantic and the Mediterranean, and rears the highest part of its curve on the Spanish territory, between the springs of the rivers Cinca and Ara. This eminence, called *Mont Perdu* by the French, is known, in Aragon, by the appellation of Tres Sorores, alluding to its three peaks, distinctly seen from Zaragoza, of which the highest, according to the French naturalist, Ramond, who examined it in 1802, rises 4114 Spanish yards above the level of the sea. The line of perpetual congelation is there at the height of 2924 yards. Till this measurement by Ramond, the peak of Canigú, on the French confines of Catalonia, had been deemed the highest point of the Pyrenees. It is, however, only 3364 feet above the sea.†

In the minor branches which strike off from the Pyrenees in a south direction, without forming a part of the great secondary chains, which we shall presently describe, there are some mountains too remarkable to be left unnoticed. Such are, the Monsein, on the coast of Catalonia, near the town of Arens, and the well known Monserrat, which rises, on the same coast, to the height of 1479 yards above the sea:—such the Sierras of Ribagorza, Barbastro, Huesca, and Jaca, which take their names from the principal cities in their neighbourhood:—such, finally, those numerous spurs of the great ridge which run into Navarre, whose various appellations would only tend to confuse the reader. The most remarkable object, among these hills, is the Higa de Monreál, probably so called from the fancied resemblance of its highest rock to a fig (Higo, or Higa). It stands about three leagues to the east of Pamplona, on the high land which divides the waters of the rivers Arga and Aragon.

Of the main ridges which run across the peninsula, that which rises to the west of the source of the Ebro was called *Idubeda* by the Romans, and formed the limits of the ancient *Celtiberia*. In its course towards the Mediterranean, the natives, according to a general custom, distinguish the various portions, or great links of the chain, by the appellation of *Sierras*, adding the name of some town or notable height in their vicinity. Such are the Sierra de Oca, of Urbión (the *Distertiæ* of the middle ages), of Moncayo (*Mons Caunus*), of Molína, Albarracín, and Cuenca. Part of this chain forms the limits of Aragon and Castille; it then penetrates into Valencia, Múrcia, and Granada, and ends in the Capes Oropesa (Tenebrium), Martin, Palos,‡ and Gata. The small town of Alcoléa, in the province of Sória, stands on this chain at the height of 1486 yards above the sea. Its mean elevation, on the road between Molína and Teruél, in Aragon, is 1580 yards.

It is this chain, which Antillon calls the *Iberian*, that, by its direction from its origin to the heights of Moncayo, drives the Ebro to the east, and feeds the Duero towards the west. The Duero proceeds, however, to the south till it comes to Almazán, where the great ridge, forming an elbow to the south-south-west, forces the stream into its westerly bed. Farther south, near the sources of the small rivers Xalón and Tajuña, the Iberian ridge, bearing the name of Sierra Ministra, divides the waters between the Tagus and the Ebro.

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* *Elementos de la Geografia Astronómica, Natural y Política de España*, por Don Isidoro de Antillon. Madrid, 1808. This is a book of great merit. Its author, whose premature death, while representing his native kingdom of Aragon in the second Cortes at Cadiz, is lamented by his numerous friends, as well as by all who, knowing his worth and talents, can appreciate the loss which his country sustained by that event, spared himself no trouble in the collection of materials for this elementary book, which he wrote for the use of his pupils at the Royal College of Nobles, at Madrid. Besides the extensive local knowledge he had acquired in his travels through Spain, these *Geographical Elements* contain a great deal of information derived from the unpublished works of other scientific Spaniards. Such is the *Ensayo de una descripcion fisica de España*, por Don Josef Cornide, printed in 1803, but which had not come into circulation in 1808. Antillon professes himself indebted to Cornide for his description of the Spanish mountains, as we are to him for our geographical account of that country, and some valuable facts relating to its statistics.

† The divisory line, between Spain and France, formed by the Pyrenees, extends from Cape Higuér, on the Atlantic near Fuenterrabía, to Cape Cervéra, north of Cape Creus, on the Mediterranean, through a space of 92 leagues.

‡ Cape Palos derives its name from the sea lagoon (*Palus*) called Albuféra, from which one of the French Marshals derived his title. It communicates with the sea by an opening, which is easily closed. The *Albufera* is valuable for the great quantities of fish, especially mullets and john-dories, that abound in it. The Cape itself was called *Scombrarium*, from the abundance of the fish *Scombrus*, a kind of mackerel, on that coast.

The first point where this great ridge splits into the minor chains which lose themselves in the Mediterranean, is to the north of Albarracín, in Aragon. Of these branches the most remarkable is that which, entering the province of Valencia, is again subdivided into the smaller ridges which terminate at Peñíscola and Cape Oropesa. The waters that descend from these heights, to the north, mix finally with the Ebro, while the Túria and the Mijares are swelled by those which flow from the southern declivities. On the branch stretching towards Peñíscola, and in the limits of Aragon, rises the Muela de Ares, * a conical mountain, deprived of its apex; whose top is an extensive plain covered with luxuriant pasture, and surrounded by fearful precipices, at the elevation of 1562 Spanish yards above the sea. This is one of the highest spots in the peninsula; the Tagus, the Xucar, and the Cabriel, take their rise among these mountains, and divide the waters which flow from their sides, between the Atlantic and the Mediterranean. Numerous flocks of sheep, both itinerant and stationary, find, in the valleys formed by this chain, the most abundant summer pastures.

From Albarracín, this chain strikes into the territory of Cuenca in a direction nearly north and south. It then sends off a branch to the east-south-east, on which the Collado de la Plata, or Silver Hill, rises 1598 yards above the sea. It contains a quicksilver mine, which was worked a few years ago, at the distance of four leagues west of Teruél. From the neighbourhood of this town the Sierra de Espadán runs, like an unbroken bulwark, to the sea near Murviedro, in a direction between south-east and north-west. The ruggedness of the hills, the terrific depth of the precipices, and the intricacy of the mountain passes, overhung with perpendicular rocks of black marble, are described in glowing colours by the great Spanish botanist, Cavanilles, whose account of a scientific tour in these highlands of his native province, Valencia, is quoted by Antillon. The Pico, which is considered the most elevated point in these mountains, rises 1303 yards above the sea. Its latitude has been determined by accurate observations to be 39° 31′ 38″. Its longitude 3° 0′ 36″ east of the meridian of Madrid.

Near the source of the Tagus, the Iberian ridge sends off another branch which, stretching in almost a southern direction, separates La Mancha from the province of Múrcia, to the west of the town of Albacéte, and rises into the lofty mountains of Alcaráz and Segúra (the ancient *Orospeda*), dividing the waters between the Guadalquivír and the Segúra, the two main streams which severally and finally convey them to the ocean and the Mediterranean. † One of the two great limbs which terminate the Iberian ridge runs into the sea at the Cape Cervéra; the other, bending to the south, skirts the kingdom of Granada, and disappears at the Cape Gata. To the latter belongs the mountain called Cabezo ‡ de María, between Cartagena and Cape Gata, one league west of the town of Vera on the coast of Valencia. It rises 2287 yards above the sea, and has its summit covered with snow during one-half of the year.

Smaller branches of this chain project between the Túria and the Cabriel, which loses itself in the Xucar at Cofrentes. A ridge runs between the last mentioned river and the Alcoy, another stream, which flows into the sea near Gandía. A minor chain separates the Alcoy and the mouth of the Segúra. The province of Valencia is, in fact, divided by mountains into most fertile stripes, watered by numerous streams, and enjoying every blessing which nature grants to the most favoured climates. The mountains on the right of the Xúcar, from Cofrentes to the sea, bear the two appellations of Cortes de Pallás and Millâres, each applying to a different portion of the ridge. To the left of the same river, the mountains are known by the names of Torres and Dos Aguas, which they change for that of Monte Caballón when they penetrate into Valencia from the province of Cuénca. The rock on which the castle of Monserrate stands, near the sea-shore, five leagues west of the lake Albuféra, may be considered as belonging to this ridge. The castle is 313 yards above the sea. From the mountains of Millares, to the right of the Xucar, another ramification projects between the provinces of Múrcia and Valencia. Before reaching Villena it bends towards the sea, on the left of the Alcoy, where it is known by the name of Sierra de Marióla. The number, purity, and copiousness of the streams, which are fed by these hills, render them the main source of wealth and comfort to the neighbouring country. The highest summit of this ridge is called Moncabrér. Another arm stretches from Villena, in which we find the Sierra de Viár, the rock of Xixóna, the mountain of Aytána, and the pyramidical mountain of Mongó, near the Capes San Antonio and Martín. The longer duration of snow on its top makes Cavanilles believe that it surpasses Moncabrér in height, especially as the latter is at a greater distance from the sea. The southernmost part of the chain, which strikes off at Villena, sends out its waters to swell the stream of the Segúra.

Before we proceed to the next main branch of the

* The insulated rocks which, rising above the ridges, terminate in a plain, are distinguished in Aragon and Valencia, where they abound, by the appellation of *muelas* (grinders).

† The Túria, though a considerable river during part of its course, is so drained by canals of irrigation, that it is reduced to a poor stream when it enters the sea. Cavanilles gives a very interesting description of that river, the constant theme of the Valencian poets. The Spanish naturalist represents the Túria, in its strength, as opening a way between the two ridges which decide the course of its waters, and presently "engaging into such fearful chasms, that, near the village of Chulílla, it rushes through a channel 600 feet deep, and not more than 50 in breadth, winding, in intricate curves, over a bed harder than common marble."

‡ The masculine termination in *o* is sometimes used in Spanish as an augmentative. Mountain heads are generally called Cabezos, instead of Cabezas. One of the beauties of the Provençal consisted in this power of varying the gender of nouns according to the colouring which the writer wished to give to his pictures. *Vide* Sismondi *Literature du Midi*, Vol. I.

Spain.

Spanish mountains, it will be proper to exhibit a general view of the Iberian chain, which we have hitherto pursued in detail. This would hardly be necessary if we possessed more accurate maps of Spain than are to be found even in that country. * In the absence, however, of a graphic representation, the course of the rivers will sufficiently indicate the great valley formed by this chain, and which might be named the valley of the Ebro. Its skirts may be traced by a line passing over the sources of the smaller streams to the south of the Ebro, first, as far as Albarracín; then, in a direction nearly west and east, to the Cape Oropésa. This latter part of the chain bears the names of Sierras de Gudar and Peñagolósa. All the rivers to the north of this ridge flow into the Ebro. From Albarracín to Cape Gata the waters are sent off, by the other branch, to the Mediterranean from the east declivity: and from the western, to the Tagus, the Guadiána, and the Guadalquivir, which convey them to the ocean.

Great Ridge between the Duero and the Tagus.

A map of Spain must be imperfect indeed which does not mark the great ridge whose summits divide the waters between the Duero and the Tagus. It grows out of the Iberian chain, not far from the sources of the Xalón and the Tajúña,† to the south of the city of Sória, and the site of the ancient Numantia. Where it divides the province of Guadalaxára from that of Sória, it is called Sierra de Parédes, and Altos de Baraona. On one of the hills, north of Siguénza, rises the Henáres, which gives its name to the ancient *Complutum*, now the seat of a Spanish University. Near the source of the Lozóya, a rivulet which runs into the Xaráma, these mountains are called Somosierra, till, more to the west, they bear the name of Guadarráma; an appellation which they preserve throughout the long course in which they skirt the provinces of Segóvia, A'vila, Guadalaxára, and Madrid. The Puerto de Navacerráda, the highest point on the road from Madrid to the summer palace of San Ildefonso, is 2204 yards above the sea. The descent to the royal residence is excessively rapid, the difference of elevation between these two points being 816 yards in the space of about three leagues.

The mountains of Guadarrama are a very striking object when seen from the neighbourhood of Madrid, on the road to Old Castille. They principally consist, according to Mr Townsend, of naked, fractured granite rocks, heaped up together, and adorned only towards their bases with single evergreen oaks, while the upper parts are bleak, dreary, and barren, presenting fantastic prominences, and in many places covered with perpetual snow.

This chain, in its course towards Portugal, where it ends in the Rock of Lisbon, rises into some remarkable elevations. We shall notice that of Peñalára, between the sources of the Eresma and the Lozoya, 2834 yards above the sea; the Puerto del Pico, in the province of Salamanca; the Peña de Francia, and Sierra de Gata, on the northern limits of Spanish Extremadura. In Portugal, this chain takes the name of Sierra de Estelha (*Mons Herminius*), and terminates under the well known appellation of Cintra. The Sierra de Estelha runs between the Mondégo and Cecere for a space of twelve leagues, where its summit expands into a plain three leagues in length, and one in breadth, containing three lakes, fed by the snow which covers that elevated spot from October till June. From one of these lakes the Mondégo takes its source.

Our limits compel us to omit Antillon's accurate and interesting description of the minor branches which run nearly north and south from the main ridge, which that writer conceives to end in Cape Finisterre. They may be traced from the opposite course of the rivers which flow either into the Duero and the Miño,‡ or into the ocean, on the western coast of Galicia.

Chain of the Tagus and the Guadiana.

Almost parallel to the mountains of Guadarrama, we find the ridge which divides the waters between the Tagus and the Guadiana. The rise of this branch out of the Iberian chain would hardly be perceptible, but for the separation of the waters, which begins in the vicinity of Huéte, south of Cuenca. The gradual elevation of the ground from Tarancón to Tembléque, in the province of Toledo, raises the latter town 740 yards above the sea. Bolder hills appear at Madrilejos; and the town of Consuégra has an elevation of 769 yards. Proceeding a short distance to the south-west, the Sierra de Yévenes clearly shows the direction of the ridge, which is soon after known by the name of Guadalúpe (Montes Carpetani); it then runs between Truxíllo and Mérida, under the name of Sierra de Marchál, penetrates into Portugal by Castél de Vide and Portoalegre, is seen to the west of Elvas and Estremóz, and descends to Cape Espichél, having Beja and Setúbal to the south, E'vora and the mouth of the Tagus to the north.

Ridge of the Guadiana and the Guadalquivír.

The third great branch of the Iberian ridge is the Sierra Moréna (*Montes Mariani*), which divides the waters between the Guadiana and the Guadalquivír. It begins in the vicinity of Alcaráz, near the eastern limits of the province of La Mancha, issuing from that spur of the Iberian chain which terminates in Cape Palos, and, trending in a direction north-east and south-west, with La Mancha, Spanish Extremadura, to the north, and Jaén, Córdoba, Seville, and Algarve (Portugal), to the south, ends in the ocean at Cape St Vincent. The pass named Puerto del

* The map which Antillon constructed for his work, though upon a very small scale, is the most accurate in existence; and we would strongly recommend it to the attention of those who devote their industry and talents to the important department of geography.

† The division of the waters occasioned by this ridge begins at these two rivers, the Xalón flowing int' the Ebro, the Tajúna, through the Xaráma, into the Tagus.

‡ We have preferred the Spanish appellations of these rivers in a description of Spain. They, in fact, differ very little from the Portuguese names. Miño and Minho express the same sound, the Portuguese *nh* being exactly similar to the Spanish ñ. Both are signs of the *gn* of the Italians.

Spain.

Rey, where the road from Madrid to Andalusia crosses these mountains, is 821 yards above the sea. Near Cordoba, where the bold skirts of the *Montes Mariani* are seen, within a short distance to the north, like a skreen raised to protect the rich and extensive plains watered by the Guadalquivír, the ridge borrows the name of the neighbouring city. On the southern limits of Extremadura, and to the north of Seville, it is called Sierra de Guadalcanál. The chain now bends to the south-west, forms the northern boundary of the Portuguese province of Algarve, and, through the Sierras of Caldeiraon and Monchíque, connects itself with Cape St Vincent.

Ridge of Granada and Ronda.

The brink of the last mountain plain towards the south of Spain is skirted by the ridge of Granada and Ronda, which, striking off at the extremity of the Iberian chain, is successively called Sierra de Gadór, Sierra Nevada, Bermeja, and de Ronda, till it ends in various points of the coast, but most conspicuously in the Rock of Gibraltar.

Part of Sierra Nevada rises above the highest Pyrenees. According to the geometric levelling performed in 1804 by Don Ramon de Roxas Clemente, the Cúmbre de Mulhacén is 4254 yards above the sea; the Picácho de Veléta 4153.* The line of perpetual congelation is found in these mountains at the height of 3305 yards.

Rivers.

In describing the principal chains of the Spanish mountains, we have already mentioned the five great streams which water the intermediate plains, the Miño, the Ebro, the Duero, the Tagus, the Guadiana, and the Guadalquivír. We will now select a few particulars relating to each.

The Mino.

The Miño, or Minho (*Minius* or *Bœnis*), rises in Galicia, in the district of Lugo, from a beautiful spring called Fuente Miña. This river is navigable only to Salvatierra, two leagues above Tuy.

The Ebro.

The Ebro rises, near Reynósa, out of so copious a spring, that it works a corn-mill a few steps from its source. After a course of 110 leagues, it flows into the Mediterranean at Alfáques. From the boundaries of Navarre to the sea, the Ebro makes a progress of 1° 12′ 42″ towards the south. The chief towns on this stream are Logróño and Calahórra, in the province of Rioja; Tudéla, in Navarre; Zaragoza, in Aragon; and Tortosa, in Catalonia. It is a misfortune for Spain that this great river presents strong obstacles to navigation, both in its course and where it joins the sea. Of the plans which have been conceived, and partly executed, to obviate these impediments, we shall presently have an occasion to speak.

The Duero.

The Duero, or Douro, has its source to the north of the city of Osma, in a deep lake, at the summit of that portion of the neighbouring chain of mountains which has been mentioned by the name of Sierras de Urbión. Its course is at first towards the south, passing by Garay and Soria, where it turns to the west, continuing in that direction till it reaches Miranda. From this town to Moncorvo the river falls again into a south direction. It lastly takes a decided course to the ocean, where it ends near Oporto, having traversed a distance of 150 leagues. The Duero advances 10′ to the south from Aranda to Tordesillas; from hence to Miranda it inclines 40′ to the north. Its mouth lies 33′ 45″ south of Miranda. This river is navigable up to the tower of Moncorvo, a space of thirty leagues. The navigation, which was formerly obstructed by rapids, has been expedited through the exertions of the Portuguese Company of Alto Douro. Some of the smaller streams flowing into the Duero, rise at remarkable heights. The Adaja, which descends from the northern slope of the great chain between the Duero and the Tagus, is, at A'vila, 1271 yards above the sea; the Eresma, when it flows by the castle of Segovia, is 1107 yards above the same level.

The Tagus.

We have mentioned that elevated part of the chain between the Tagus and the Guadiana, which takes the name of Albarracín, and the truncated mountain called Muéla de San Juan. An inconsiderable spring, denominated Pié Izquierdo, is the source of the majestic Tagus. In its course through the province of Cuenca it is considerably augmented by the contributions of several streams. Before its waters reach Aranjuéz, they surmount the rocky edge of its native mountain, and, dashing upon the plain beneath, sink into a pool of great depth, called Olla de Borláque. The Tagus, now running placidly through the plains of Zoríta and the royal gardens of Aranjuez, at the elevation of 621† yards above the sea, directs its course to Toledo, passes by Talavera, Alcántara, Abrantes, and Santarem, losing itself finally in the sea, near Lisbon. The latitudes of several towns on the banks of the Tagus show the gradual inclination of its stream toward the south. It amounts to 49′ 6″ from Trillo to Toledo, to 6′ 24″ from the latter city to Alcántara, and no less than 1° 1′ 40″ from thence to the capital of Portugal.

The Guadiana.

The river Guadiana is, according to Antillon, very inaccurately represented in the Spanish maps of Lopez, both as to the point where it disappears, and that where, emerging from the ground, through which its waters are filtered, it resumes its sluggish course to the ocean.

The sources of the Guadiana have been rendered classical ground by the pen of Cervantes. They are found north of Alcaráz, in La Mancha, at the pools of Ruidera, well known to the admirers of *Don Quixote*. The course of the river is first to the north-west, for eight leagues. It is then absorbed by the soil, and disappears for seven leagues. The first gathering of its waters, after their subterraneous dispersion, takes place near Daymiel. The spot is called Ojos (Eyes) de Guadiana. The stream now proceeds to Ciudad Reál, the head town of the pro-

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* The result of this, and several other measurements executed by Mr Clemente, was communicated to Mr Antillon, who has given them in his work, with the initials R. C. Those relating to Sierra Nevada have later been published in the *Annales de Chimie*, Vol. XX. p. 99.

† This barometric measurement was taken by Humboldt in 1799.

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vince of La Mancha, to Mérida, Badajóz, Mértola, in Portugal, and, re-entering the Spanish territory, terminates in the ocean at Ayamonte. In its course to this point, the Guadiana passes over a space of more than one hundred leagues.

The abundance of pasture which betrays the hidden course of Guadiana is the origin of a boast often repeated in La Mancha, that their river has so broad a bridge as to allow thousands of cattle to feed upon it.* That bridge affords, however, but a dangerous pastoral station; for the country being subject to sudden inundations, both flocks and shepherds are not unfrequently in the most imminent danger of being swept away by the waters. The stream of Guadiana, near Villarta, is only at the height of 710 yards above the sea. It is not navigable higher than Mértola in Portugal.

The Guadalquivír.

The Guadalquivír occupies the centre of the plain which lies between the Sierra Moréna and the chain of Granada, where it takes its source to the north-east of Jaén. The chief towns on its banks are Andújar, Córdoba, Seville, and San Lúcar (*Templum Luciferi*). At the ferry near Mengíbar, on the road from Madrid to Granada, the Guadalquivír is 203 yards above the sea.† The Guadalquivír is navigable for large vessels up to Seville; but its bed being constantly raised and obstructed by growing shallows, the navigation is extremely tedious.‡

Population of Spain.

II. On the subject of population, the data which the Spanish government possessed before the French invasion must have been greatly deficient in accuracy. The suspicions of the inhabitants, constantly alive against every public measure, were roused into full activity by the domiciliary inquiries which took place in 1798, when a general *census* was made. It is, therefore, more than probable, that the number of inhabitants considerably exceeded what we find in the official reports. We subjoin the Table published by Antillon from documents in the possession of the Commissioners for the Encouragement of Trade (*Balanza Mercantil, y Fomento de Comercio*), in 1803.

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A Table of the Population of Spain in 1803.

Provinces.	Total of Inhabitants.	Surface in square leagues, 20 to a degree.	Inhabitants to square league.
Province of Madrid§	228,520	110	2078
Guadalaxára	121,115	163	743
Cuénca	294,290	945	311
Toledo	370,641	734	505
Mancha	205,548	631	326
A'vila	128,061	215	549
Segovia	164,007	290	566
Sória	198,107	341	581
Burgos	470,588	642	734
Extremadura	428,493	1,199	357
Kingdom of Cordoba	252,028	348	724
Jaén	206,807	268	772
Seville	746,221	752	992
Granada	692,924	805	861
Colonies of Sierra Morena	6,196	108	57
Kingdom of Múrcia	383,226	659	582
Aragon	657,376	1,232½	534
Valencia	825,059	643	1283
Principality of Catalonia	858,818	1003	856
Island of Majorca	140,699	112	1256
Minorca	30,990	20	1550
Ibiza and Formentera	15,290	15	1019
Kingdom of Navarre	221,728	205	1082
Province of Biscay	111,436	106	1051
Guipuzcoa	104,491	52	2009
A'lava	67,523	90½	746
Principality of Asturias	364,238	308½	1180
Province of León	239,812	493	486
Paléncia	118,064	145	814
Salamanca	209,988	471	446
Valladolíd	187,390	271	692
Zamóra	71,401	133	537
Toro	91,370	165	590
Kingdom of Galicia	1,142,630	1,330	859
	10,351,075	15,005½	690

* The Spaniards of old times delighted in this kind of startling metaphors about their country. In the same taste, they would say that the King of Spain had three noble subjects, who brought into the field six thousand knights, wearing gold spurs, meaning the Grand Masters of Santiágo, Alcántara, and Calatráva; that he had a lion (*León*), and a bull (*Tóro*), that fed daily on twelve beeves, in reference to the towns bearing these names; that he had three dogs (*Canes*), who served him with two hundred Castillian lances, such being the military service due by the three towns Can de Roa, Can de Muna, and Canes de Zuríta. *Can* is the Castillian pronunciation of the original Spanish word *Camp*, which afterwards became *Campo*, a field, or district.

† The following barometric measurements show the rising of the ground from that point to Alcalá la Reál, where the waters are divided between the Guadalquivír and the Geníl. Mengíbar is 350 yards above the sea; Torre-Campo, at the distance of four leagues, 705; Alcaudéte, five leagues, 835; Alcalá, three leagues, 1023.

‡ The Guadalquivír was navigable up to Cordoba in 1360, as appears by a petition of the Seville bargemen to Peter *the Cruel*, complaining that the openings required by law across the mill-dams had been narrowed, and, in some cases, closed against them. The king ordered the obstructions to be removed, and fixed for the breadth of the channel that of an arch in the cathedral of Cordoba, called the *Arch of Blessing*. *Crónica del Rey Don Pedro, anno* 1360, p. 309.

§ In comparing the respective population of the Spanish provinces, the inhabitants of Madrid, amounting to 168,000, should be excluded as adventitious, and mostly belonging to other parts of the kingdom.

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*Population of Portugal, from the Official Returns of 1798.**

Provinces.	Total of Inhabitants.	Surface in square leagues, &c.	Inhabitants to the square league.
Entre Douro e Minho	907,965	291½	3115
Tras os Montes	318,665	455	700
Beyra - -	1,121,595	753	1498½
Extremadoura	826,680	823	1004½
Alentejo -	380,480	883	431
Algarves -	127,615	232	550
	3,683,000	3437½	1071

Taking a general view of the population of Spain, it appears to have been distributed, in 1803, over the 15,005½ square leagues of its surface, in the following proportions:

	Inhabitants to the square league.
Maximum of population—province of Guipuzcoa - -	2009
Minimum—province of Cuenca	311
North maritime provinces, collectively (Galicia, Asturias, Burgos, Biscay, Guipuzcoa, and Catalonia)	887
South maritime provinces, collectively (Valencia, Múrcia, Granada, and Seville) - - -	926
Northern provinces of the interior, collectively (León, Paléncia, Zamóra, Toro, Valladolíd, A'vila, Segovia, Sória, Guadalaxára, A'lava, Navarre, and Aragon) - -	604
Southern provinces of the interior, collectively (Salamanca, Extremadúra, Córdoba, Jaén, Mancha, Toledo, and Cuenca) - -	428
Maritime provinces, collectively -	904
Inland do do -	507

Influence of the Extent of Sea Coast on Population.

The facilities afforded by an extensive sea coast, for the subsistence and consequent multiplication of the neighbouring inhabitants, appear in a striking light when the following facts are taken into consideration:

The extent of coast from Cape *Cervéra* to Cape Trafalgar is 251½ leagues; from the latter to Cape Finisterre it amounts to 262 leagues; from that point to Cape Higuér there is a line of 143 leagues. The subjoined Table exhibits the proportion of coast possessed by the maritime provinces of Spain and Portugal, compared with the areas of their territories. We shall add a column containing the number of inhabitants to the square league, that the reader may have all the necessary data before him:

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Provinces.	Extent of Coast.	Ratio of the Coast to the area, the latter being represented by 1000.	Number of Inhabitants to the square league.
	Leagues.		
Catalonia -	68⅔	1000: 68	856
Valencia -	69	: 107	1283
Múrcia -	21	: 32	582
Granada -	74	: 92	861
Seville (19 leagues on the Mediterranean, 35 on the Atlantic)	54	: 72	992
Algarve (Portugal)	43	: 185	550
Alentejo, do	19	: 22	431
Extremadoura, do	60	: 73	1004½
Beyra, do	23	: 31	1489½
Entre Douro e Minho, do	27	: 93	3115
Galicia -	110	: 83	859
Asturias -	40	: 130	1180
Burgos -	27	: 42	734
Biscay -	13	: 123	1051
Guipuzcoa -	9	: 173	2009

It appears from the preceding table, that Guipuzcoa, Asturias, and Biscay, are the most populous provinces of Spain; and that the excess of their population is nearly in the ratio of their coast to their territory, compared with the other divisions of the country. If Valencia, with less coast to its area than Biscay or Asturias, is more peopled than either, the extraordinary fertility of its soil, and the unrivalled salubrity of its climate, will easily account for the anomaly. The province of Granada, which possesses a greater proportion of coast than Galicia, is also more thickly inhabited. The same may be observed in comparing Galicia with Catalonia, Burgos with Murcia. Antillon attributes the excess of population in the province of Seville over Granada to the conflux occasioned by the two great towns of Seville and Cadiz, both enjoying peculiar advantages; the former from its sea-port, the latter from the navigation of the Guadalquivir.

The comparison of Portugal with Spain affords a further confirmation of this theory. The latter kingdom has 468 leagues of sea coast, Portugal 172. The ratios of their areas to their line of coast are 100 : 3,24—and 100 : 5. Now, in the *first* place, The mean population of Portugal exceeds that of Spain by 381 inhabitants to the square league; *2dly*, The most populous province of Spain falls short of the most populous in Portugal by 1106 souls to the same portion of territory; *3dly*, In the respective provinces where population is thinnest, the Portuguese exceed the Spaniards at the rate of 120 persons to the square league.

If we compare the population of the Portuguese provinces with the ratio of their areas to their line

* These Tables are inserted here for the convenience of the reader, who would otherwise be obliged to keep the article *Portugal* constantly under his eye, in order to judge of the observations we shall presently make on the comparative population of the two peninsular countries. The Portuguese returns reckon by *fogos* (hearths), which Mr Antillon has calculated at the rate of five persons to each.

of coast, we shall find that Alentejo, the lowest in that scale, is also the least populous. Entre Douro e Minho, which has a greater proportion of coast than Beyra and Extremadoura, is more inhabited than either.* If the relative population of these two appears to be an exception, the fact may be easily explained by the consideration, that Beyra, besides the Mondégo, and some other copious streams, enjoys the navigation of the Douro and the Tagus from the farthest limits of its territory, while Extremadoura has only a share in the benefits of the latter river. Entre Douro e Minho, possessing the Douro, the Lima, and the Minho, which are navigable a great way up the interior, may be reckoned to exceed Algarve in the advantages arising from a sea-coast, though the sea washes a smaller portion of its territory. The difference, too, of the soils affords an additional answer to the objection, since that of Entre Douro e Minho is confessedly the richest in Portugal, while the inhabitants of Algarve have the most sterile portion of the kingdom for their lot.

Whatever may be thought of the accuracy of the preceding theory, it cannot be denied, that, besides the great quantity of food afforded by the sea, the facility of communication and conveyance, which a neighbouring coast presents, must have a direct tendency to increase the wealth of the inhabitants, and consequently to multiply their numbers. The territory of Spain has been quaintly, though accurately, compared to an embroidered waistcoat; the edges full and ornamented, the centre a blank, with a few scattered flowers. Were it all as fully inhabited as Guipuzcoa, it would contain 30,146,050 souls, nearly three times the number in 1803. Even at the moderate rate of the Catalonian population, or 856 souls to the square league, Spain would have 12,844,708 inhabitants, about two millions and a half above the last returns. That this comparative dearth of population does not, either exclusively or chiefly, arise from the national system of government, is proved by the state of population in Portugal, a country which, from time immemorial, has been no less than Spain, under the influence of political and religious despotism. Capmany,† one of the most able and well informed Spaniards of our own times, has satisfactorily shown, that the accounts of some old writers, who make the population of Spain, in the sixteenth century, ascend to twenty or twenty-one millions, are groundless and exaggerated. We are, therefore, inclined to attribute more influence on this point to the physical or geographical circumstances of Spain than has been hitherto allowed by writers on Spanish statistics, and shall give it the first place in the consideration of the chief obstacles which have hitherto opposed the prosperity of that country.

Obstacles to the Prosperity of Spain.

III. No depth of observation is required to perceive that, whatever opposes the internal trade and interchange of commodities, must, by checking the progress of wealth, check also the increase of population; while a mere glance at a good map of Spain will suffice to perceive how unfavourable the structure of that country must be to the purposes of national commerce. The enormous chains of mountains which traverse the peninsula in a direction almost parallel to the equator, and the consequent want of navigable rivers from north to south, the distance from the central provinces to the coast, the difficulty of cutting roads and canals through high ridges of mountains and extensive plains at very different levels, are obstacles which would require all the activity of a rich and well governed nation to smooth or to subdue.

Little, however, could be expected from the enfeebled and corrupt despotism into which the government of the Spanish Bourbons had settled after some fitful aims at improvement, which a court intrigue or the death of a minister was sure to defeat. Yet, it is but justice to say, that the only progress which Spain has made, since the time when the foreign influence of her monarchs, and the discovery of America, gave her a false appearance of internal vigour, has taken place under the present dynasty.‡ How much was done for the encouragement of agriculture, in the reign of Charles III., may be deduced from the fact that, whereas that monarch found Spain under the annual necessity of importing corn § to the value of one hundred millions of francs, the deficiency was found so far reduced under his successor as to be supplied, in the more favourable years, at the expence of only fifteen millions of the same money. ||

How truly the necessity of importing corn arises from the want of easy communications between the provinces, appears from the average crops which, as we learn from the demi-official authority just quoted, amount to more than seventy millions of quintals by weight.¶ In the kingdom of Aragon, there is an annual surplus of 388,000 *cahices* (2,910,000 bushels) of corn.** The incorrectness of Spanish statistical documents is, however, so evi-

* In the comparison of the Portuguese provinces it must be remembered, that Extremadoura includes the adventitious population of Lisbon.

† Capmany, *Questiones Criticas.*

‡ See a *Memoir* of the Count of Floridablanca, published by Archdeacon Coxe as an Appendix to the 1st volume of his *History of the Spanish Bourbons.*

§ The quantity of corn supposed to be imported yearly into Spain is sixty millions of fanegas, or one thirteenth of the whole consumption. Upon a rough calculation, two fanegas are equal to three bushels.

|| *Histoire de la Guerre d'Espagne contre Napoleon Buonaparte, par une commission d'officiers de toutes armes établie à Madrid auprès de S. Ex. le Ministre de la Guerre : truduite de l'Espagnol, avec notes et eclaircissements par un temoin oculaire.* Tome I. Introduction, p. 120.

¶ Ibid. p. 118.

** Antillon, upon the authority of a Memoir which obtained the prize in 1799 from the Aragonese Society. *Geografia de Espana*, p. 151, 2d edit.

dent, that it would be rash to admit any inferences from them implicitly, or to their full extent. Yet, it cannot be doubted, that, in years of abundance, the produce of the interior is often allowed to waste, while corn is imported from Africa and Russia at a cheaper rate than the native produce could be sold for on the coast.

The benefits of the exportation of wine, which are now limited to some of the provinces bordering on the sea, might be extended to more than one-half of the country if, by means of canals or navigable rivers, that article could be transported to the coast at a cheap rate. But the luxuriant vineyards of Andalusia, not in the immediate vicinity of the water, are of little advantage to the owners; and the juice, which might ferment into a variety of exquisite wines, is often thrown away, when the small quantity, which will supply the demand of a very limited district, has been collected in the cellars.

Internal Navigation.

The water carriage in Spain is reduced to the inconsiderable portions of the intended canals of Aragon and Castille, which have been constructed; to the slow and laborious navigation of the Ebro from Zaragoza to Tortosa, performed, almost exclusively, for the conveyance of wheat; and to the floating of timber down that river, the Tagus, the Xúcar, the Segúra, and the Guadalquivir. This last river, on which a steam-boat, built and worked under the direction of a British engineer, affords, of late, an easy and speedy communication between Seville and San Lúcar, is the only one from which Spain derives any considerable advantage in point of trade.

It may be reckoned among the unfortunate combination of circumstances which have hitherto checked the internal prosperity of Spain, that the navigable part of its finest rivers belongs to another kingdom. The Tagus and the Douro may be said to exist for the exclusive advantage of Portugal.

During the short and ill-fated union of the two peninsular crowns, the engineer Antonelli undertook to open the navigation of the Tagus as far as Toledo, and completed that useful work in 1558. After the separation of Portugal from Spain, several plans have been presented to the Spanish government for removing the obstacles which obstruct the bed of that river from Alcántara to Toledo, and even from the latter town to Aranjuez, which, by means of canals, was to be joined with Alcalá. Surveys were made by order of the government, from which, as Antillon observes, no benefit accrued to the country except an accession of topographical knowledge, and the fruitless conviction that the communication of La Mancha with the ocean was opposed, chiefly, by moral and political obstacles.*

The Ebro, under the Roman dominion, is said to have been navigable up to Logróno, a distance of 65 leagues inland. In the twelfth century, the Emperor Don Alonso ordered gallies to be sunk near Zaragoza, as a defence against the Moorish navy. Zuríta relates, that, in the fifteenth century, King Don Juan sailed down the Ebro from Navarre into Aragon. We find, however, the Cortes of the latter kingdom, under Charles II. of Spain, towards the end of the seventeenth century, deliberating upon plans for expediting the navigation of the Ebro near the sea. A survey was made for the same purpose in 1738, but with no practical result. The grand canal of Aragon was at length begun under Charles III., the grandfather of the present king; and were it completed, it would stand a splendid monument of the spirit of the nation.† It is, however, much against the practical utility of the public works undertaken in Spain, that, by a natural disposition of the people, they are all begun upon a scale which would require the wealth and power of imperial Rome for their completion. The little that exists of the canal of Aragon might, if we believe Antillon, compete with the works of that period; but, instead of reaching the sea through the Ebro, and terminating in an artificial harbour, as was intended, it has been carried on for the space of eighteen leagues only, and contributes but little to the internal navigation of the country. Whether it is more favourable to agriculture, by the copious irrigation which it affords in its course, is, we find, a point in dispute among the Spaniards. Jovellanos, in his excellent *Informe sobre la Ley Agraria*, mentions the farmers' complaints against the canals for irrigation. It is hard, indeed, upon all land owners within a certain distance to be forced to pay a tax for irrigation, whether they have or not the means, the skill, or the inclination, to avail themselves of the proffered benefit.‡ The farms, for instance, near the canal of Aragon, from Zaragoza to Sástago, pay one-fifth of their corn, and one-seventh of all other produce, for irrigation. Lands newly brought into tillage pay only one-sixth of the corn, and one-eighth of the other produce.

Such complaints, it seems, were louder in the vicinity of the canal of Castille, where the Spanish practice of allowing the fields to lie fallow every other year was still adhered to, notwithstanding the abundance of water.§ This canal begins at Alár del Rey, in the province of Burgos. It is fed by the Pisuerga, whose right bank it follows till it joins that stream on the limits of the kingdom of León. It then runs to the south and south-west, crossing the river Cierza, and proceeds on its right bank till, passing through the Carrión, it turns to the west of Palencia, and terminates in the same river. The small canal of Campos, running more to the west, joins that of Castille to the north of Palencia.

According to one of these gigantic plans with which the Spanish government have often amused their vanity, providing, as it were, in the magnitude of the enterprise, a ready excuse for their inactivity,

* Antillon, *Geogr. de España*, p. 162.

† The canal of the Ebro was begun under the Emperor Charles V., but being soon discontinued, the present canal is, properly speaking, a modern work.

‡ Jovellanos, *Ley Agraria*, p. 29.

§ Ibid. p. 39.

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the canal of Castille was to reach the sea at Santander, through the river Camésa, through the Ebro, near Reynosa, and finally through the Besaya and the Pas. From its present termination near Palencia, it was, on the other side, to reach Valladolid, to strike off from the Duero, in order to join the Adaja, and then to follow the Eresma as far as Segovia. From thence it was to be directed to the canal of Aragon, and thus to unite the ocean with the Mediterranean, across the kingdom. Don Ramon de Pignatelli, the engineer who superintended the works of the canal of Aragon, laid the plans of this immense work before Charles III. whose sanction they received. We must, however, remind the reader, that the only traces which exist of this mighty dream attract but faintly the notice of the traveller, near Burgos, and in the vicinity of Madrid, where the head of one of the intended branches extends for four or five miles almost undisturbed by barge or boat

Such are the effects of a despotic government, even in its kindest moods, and when it, fairly and honestly, means to promote the good of its subjects. Unwilling to consult, and unable to ascertain the real opinion of those immediately concerned in the result of its measures, it moves with ponderous haste towards the object which dazzles its eyes, often crushing in its way those it meant to relieve. Complaints are heard at length; which, joined to the exhaustion attending all unnatural exertions, never fail to put the despot in a passion with his subjects, and make him repent that he ever was so good and gracious as to try to improve their condition.

Had the Spanish farmers of the different provinces been fairly heard before their lands were indiscriminately drenched, in virtue of a royal decree, the treasure which was thus mispent might have been employed in opening roads across the provinces, by means of which the value of their crops would have risen at once. But the purblind projectors of these schemes forgot every circumstance of the case, except that, in the provinces bordering on the Mediterranean, irrigation increased agricultural produce. This was enough to convince them that it would have the same effect in the centre of Castille. The farmers declared, however, that the abundance of water deteriorated their lands; and, though much abused for their ignorance, they probably were in the right. Yet, supposing that irrigation could double their crops, they still had good reason to complain that, under the burden of an additional tax, the abundance of corn only lowered the price in the small district which formed their market; and that living, as they do, at the distance of many miles from their fields, they could not bestow that constant labour and attention, which alone might enable them to raise a yearly crop on the same soil.

Want of Rural Population.

We have just adverted to another of the great obstacles which oppose the agricultural wealth of Spain. The want of rural population, and the great distance of the farmers' dwellings from their farms. Independently of the loss of time and strength arising from a walk of four or six miles before the day's work is begun, there are long periods in the year when the fields are scarcely visited by the owners, generally gentlemen farmers, and but seldom by the rustic, who acts as steward. Field work, in fact, is not continued throughout the year, but hastily and slovenly performed, at the sowing and the reaping season, by large parties of labourers, for whose accommodation, in farms at considerable distance from any town, there is a building not unlike a large barn, which affords a promiscuous shelter to man and beast. Bands of ploughmen, with thirty or forty team of oxen, are seen at the beginning of winter, slightly turning up the sods in the fields which have lain fallow the preceding year. The sowers walk slowly behind them, scattering the seed by handfuls, of which, part is picked up by the large flocks of birds which hover over those extensive solitudes, and part prevented from taking root by being improperly lodged in the earth. The harrow is hardly known in Andalusia, and weeding is an operation seldom resorted to. The corn-fields, thus abandoned to the influences of the climate, and the rank luxuriance of the soil, present, at the approach of summer, the colours of the rainbow to the eye of the traveller, who, but for the absence of all human habitation, might easily mistake them for flower gardens. We are, it is true, describing the Andalusian method of farming, with which we are best acquainted; but, with the exception of Murcia, Valencia, and Catalonia, on the coast, and part of Aragon, in the interior, we have reason to believe that agriculture is neither better understood nor practised than in Andalusia; the mismanagement of whose extensive and fertile plains has, by far, the greatest share in the agricultural disadvantages of Spain. Indeed, Andalusia and Aragon, alone, might, under an active and enlightened system of tillage, supply the whole country with corn.

Projects for the Encouragement of Agriculture.

It was once proposed to the Spanish government to distribute the uncultivated land, amounting to a large proportion of the whole country, among such of the natives as were disposed to bring their lots into tillage. This measure, it was hoped by Jovellanos, would tend to a wider and more equal distribution of the Spanish population, now crowded in towns at great distances from each other. But it is hardly less difficult to alter the original and confirmed constitution of the body politic than of the animal frame. The constant state of warfare against the Moors obliged the Spaniards, from the earliest period of that protracted struggle, to live in large towns, where they might find security against the surrounding enemy. The necessity also of arming the whole male population saved Spain, it is true, from that degraded state of vassalage, which so long oppressed the greatest portion of the people of Europe; but the want of a class of men bound to the soil, and forming part of the agricultural stock of their masters, prevented the existence of a numerous peasantry, which, being spread over the country, might, in the course of time, obtain their emancipation, and become the fathers of a free and happy agricultural population.

Under these circumstances, all schemes to alter the form and character which the growth of centuries has given to civil society in Spain, must prove,

we fear, vain and visionary. It is not in the power of man suddenly to convert the idle and degraded inhabitants of large cities into sober and industrious farmers; nor, even if that were possible, could such a nation find means to furnish the home colonist with stock and implements, as well as support, till the new broken land should yield enough for their maintenance. Men will soon find their way to every spot, where either nature or the aggregate industry of the people that inhabit the country, affords them the means of living by moderate exertion. Whenever the Spanish government shall have opened an easy communication between the central provinces and the coast, and joined every important town in the peninsula by cross roads—when the means of internal traffic shall have opened a market for the produce of the soil—when the laws which fetter the industry of the Spaniards shall have been repealed long enough to allow them to perceive their real interests, and to exert themselves with the steadiness and confidence of habitual freedom, then, and not before, will the productive power of their land be called into action. Cultivation will gradually spread from the insulated spots which it always presents in its first stages; towns will join hands across deserts, and men will start up as it were from the furrows—a truth, we believe, recorded in fable by primitive philosophy, and placed in the light of demonstration by that which is the boast of our own times.

Wrong Notions on Landed Property.

Before we close this part of our article, we cannot omit to mention an obstacle to the prosperity of Spanish agriculture, which, limited as we are for space, we would pass over in silence, were it not a curious instance of the influence of national circumstances upon ideas and sentiments which habit often represents as natural and invariable.

The rights of property in land, wherever the feudal system has existed in full vigour, are so exclusive and peremptory, that it must surprise an Englishman to learn, that there are but very few spots in Spain which the landlord can call his own, from the moment he has housed the harvest. The right of driving cattle into the stubble-fields is claimed and maintained with great obstinacy, not only by the powerful association of owners of *Merino* flocks, called La Mesta, but even by the poorest individuals. The arable land of Spain becomes, in fact, a vast common, every year, to which the lord has no more right than any one else. The privilege enjoyed by the Andalusian farmers of inclosing one-ninth of their fields from Michaelmas to May-day is, according to Jovellanos, who was for some years a judge in the Supreme Court of that province, the source of perpetual law-suits;—a proof of the impatience with which it is borne by the mass of the people.

If we seek the origin of a prejudice so injurious to agriculture, so incompatible with every improvement in husbandry, we shall find it in the peculiar state of the country to which we have attributed the want of a rural population. The Spaniards, while recovering their country from the Moorish usurpers, could hardly consider any land as properly their own but what they had inclosed within the strong walls of their towns. All that the farmers could wish for was to escape an inroad of the enemy while the crops were on the ground. As they could not think of inclosing or improving any particular spot, they cared not whose cattle picked up a scanty feed upon their stubble-fields. When, by the gradual retreat of the Moors, the rights of exclusive property upon land might have been asserted by the owners, their very limited knowledge of agriculture did not allow them to see the advantages which might be derived from inclosures. Thus, in the course of centuries, the general right of pasture was established, which, from the immediate, though paltry, advantages it confers on the multitude, will, we fear, be found among the most intractable prejudices of the Spaniards.

Merino Sheep.

Connected with the ignorance of the advantages arising from the exclusive rights of property in land, are the exorbitant privileges which the Spanish laws have granted to the owners of migratory or *Merino* flocks. From the mountains of Leon to the farthest limits of Extremadura, the members of the *Mesta*, an association composed of the wealthiest Grandees, gentlemen, and religious bodies, have a right to graze their sheep on a broad belt of land called Cañada, gradually and slowly changing their stations, as the mild winters of the south clothe the earth with grass, or the heat of summer thaws the snows of the Leonese mountains. The privileges of this body are defended and enforced by a court of judges created for that purpose, and in the appointment and pay of the *Mesta*, who, with a numerous host of dependants, are the terror of the agriculturist wherever their jurisdiction extends. Lands upon this pastoral road are scarcely the property of any but these formidable shepherds, who fix the price of pasture, obtain it by compulsion wherever it is found, and look upon farmers and their labours as the natural rivals and impediments to their gains. The total of Merino sheep was calculated in 1808 at six millions. A great part of that number were stationary in the different provinces, the fineness of the wool depending entirely upon the breed, and not on the change of soil.

Since Spain, however, seems to have no chance of becoming a manufacturing country, and must depend for wealth on her natural productions, we readily agree with Jovellanos* as to the necessity of encouraging the growth of wool, an article which, for centuries, has constituted one of the main resources of that kingdom.† To balance the contending

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* Jovellanos, *Ley Agraria*, p. 47.

† The importation of the Merino sheep from England into Spain is a fact recorded both by Spanish and English authorities. It appears to have taken place at three different periods. The Bachellor Fernan Gomez de Ciudad Real, physician to John II. of Spain, says, that " the office of Judge of the *Mesta* had always been conferred on honourable Hidalgos."—" The first (he continues) was Iñigo Lopez de Orosco,

Spain.

claims of the pastoral and the agricultural interests in Spain, must be the work of time under a wise legislature.

State of Commerce and Industry.

IV. We have, in vain, tried to procure a satisfactory account of the state of commerce and industry in Spain. All we can find in the books which we have consulted amounts to little more than general complaints upon this topic. The only substantial fact contained in the first volume of the *History of the late War*, published by the government of Ferdinand VII., is that, in 1808, the annual exports of Spain were to the imports as three to seven; the value of the former amounting to seventy-five millions of francs (we leave the denomination unaltered), while the latter rose to one hundred and twenty-five millions of the same money. "In 1802 (say these official historians),* the produce of our industry was calculated at three hundred and fifty millions of francs; but it was soon reduced to much less in consequence of the maritime war (with England), and the malversations of the Prince of the Peace. The effects of these checks were the more felt, as the remittances from the American colonies were inadequate to cover the deficit. Our industry in 1808, represented by the amount of its produce, was to that of France nearly as seven to forty."

"Our commerce in 1802, soon after the peace of Amiens, was to that of France as two to three—such, at least, is the result of the statistical documents published by the continental powers at that period. But according to the more accurate estimate presented to government by Mr Canga Arguelles, in 1803, the proportion was that of twenty-eight to one hundred and eighty-two, which, in fact, differs but little from the preceding."

"When Great Britain declared against us, in the following year, our commerce, which was just beginning to recover from the losses of the past war, may be said to have received its death wound. Our mercantile companies, then the most powerful in Europe,† were ruined by the general stagnation of trade, by the large and frequent loans made to a government, who never paid either interest or principal. The *Philippine Islands Company*, whose funds were immense, failed to the amount of six millions (of francs). The *Deputation of the five Gremios of Madrid*, well known to all Europe for its credit and wealth, was ruined, partly by the inactive state of our industry, partly by the financial operations

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whom King Don Alonso (XI.) appointed to that office when the sheep were first brought from England in the Carracks." (*Centon Epistolario*, Letter 73d, dated 1437.) The appointment of Iñigo Lopez was made in 1329. (See a note to the *Chronicle of Peter the Cruel*, p. 60. Madrid, 1779.) The second importation was in the reign of Henry III. of Castille, and formed part of the marriage portion of his wife, Catharine Plantagenet, daughter of John of Gaunt. (See *Historia de la Vida y Hechos del Rey Don Henrique Tercero de Castilla*, por Gil Gonzalez Davila, p. 11.) This marriage was celebrated in 1388. (Ib. p. 4.) The third importation is mentioned by Holinshed (Vol. II. p. 668), who relates that, in 1466, Edward IV. of England "concluded an amitie and league with Henrie King of Castile, and John King of Aragon, at the concluding whereof he granted licence for certaine Cotteshold sheepe to be transported into the countrie of Spaine (as people report), which have there so multiplied and increased, that it hath turned the commoditie of England much to the Spanish profit." Stowe (p. 419) repeats the account of Holinshed; but adds, that "long ere this were sheep in Spaine, as may appeare by a pattent of King Henry the Second, the 31 of his raigne, granted to the weavers of London, that if any cloth were found to be made of Spanish wool mixed with English wool, the Maior of London should see it brent."

From this regulation of Henry II., it may be inferred that Spanish wool was, at that time, inferior in quality to English wool, and this conclusion is confirmed by Capmany, who remarks, that, till the middle of the fifteenth century, the Spanish wool could not be brought into competition with that of England, for the fine manufactures of Florence and Flanders (*Questiones Criticas*, p. 9); which again agrees with the complaints of Stowe, Harrison, Speed, and Sir Richard Baker, that Spanish wool was so much improved in their days as to rival that of England.

It cannot, however, be doubted that the travelling flocks, called *Trashumantes*, were known in Spain long before the importation of sheep from England; as the *Concejo de la Mesta*, which was created for the preservation of their privileges, possess a charter dated 2d of September 1273. (See *Quaderno de la Mesta*.*)

The custom of changing the stations of the flocks according to the seasons, the Spaniards must have derived from the Romans, whose practice on this point of rural economy is thus described by Varro: "Illæ (oves) in saltibus quæ pascuntur—et a tectis abeunt longè, portant secum crates aut retia quibus cohortes in solitudine faciant, cæteraque utensilia; longe enim et late in diversis locis pasci solent, ut multa millia absint sæpe hybernæ pastiones ab astivis. Ego vero scio, inquam, nam mihi greges in Appulis hybernabant qui in Reatinis montibus æstivabant." *De Re Rust.* Lib. II. c. 2.

* For the most valuable part of this historical information we acknowledge ourselves indebted to the friendship of John Allen, Esq. of Dulwich College.

* Introduction, p. 123, *et seq.*

† The military historians seem not to have recollected the existence of the East India Company, in England. It is certainly to be regretted that habits of inaccuracy and exaggeration still prevail too much among the Spanish writers, especially upon subjects connected with national feeling.

of our ministers. Neither the *National Bank* of *San Carlos*, which opened with a capital of seventy-five millions (of reals, about seven millions and a half Sterling), nor the *Royal Maritime Company*, created in 1789, could realize their objects, or even preserve their funds, which were soon drained, to fill the strong chests of the Favourite, or spent in France for the support of armies which were, at no distant period, to be employed against us."

"The failure of remittances from Spanish America, the enormous subsidies which we paid to France, and the ruinous measures by which the annual deficits were met, exhausted the treasury, and put an end to public credit. No funds were safe from the hands of the Favourite. The capital of the bank, that of the *Monte de Piedad*, the judiciary deposits, the pauper's fund,—all was seized by servile ambition, that it might support injustice and prodigality. The plans of internal navigation were forgotten, the public works then in progress were suspended, and those that had been concluded were left to decay for want of means to repair them."

"The government, wholly intent on guilty schemes of momentary advantage, not only neglected the country whose interests it was their duty to promote, but actually increased the obstacles which were opposed to her industry. Customhouses were found in every direction, the roads were crowded with revenue officers, and tolls were levied, at every step, upon travellers. The merchants were compelled to make declarations injurious to their interests; and, when they had gone through ten thousand vexatious forms, they could not yet feel secure, or beyond the reach of the fiscal vultures."

Recent History.

V. Such was the state of Spain in 1808, when the ambition of France, and the dissensions of the royal family, brought her to that dangerous crisis, of which the extraordinary events of the last fifteen years are not sufficient to point out the issue. We must, however, refer the reader for a sketch of that part of Spanish history to the Article GREAT BRITAIN in this *Supplement*; and attempt a more detailed view of the period beginning with the return of Ferdinand VII. from his captivity in France, and ending in the invasion of the French army in 1823.

New Constitution of Spain.

The hopes which had induced some of the most enlightened Spaniards to join in the popular struggle against the establishment of Joseph Buonaparte on the throne of their country, had been crowned with success on the publication of the New Constitution, at Cadiz, on the 19th of March 1812.

By one of the first articles in that code, the sovereignty is declared to reside essentially in the nation, which, being free and independent, neither is, nor can be, the patrimony of any person or family. —All Spaniards, without distinction, are subject to taxation.—"The religion of the Spanish nation is, and shall be for ever, the Catholic, Apostolic, and Roman, which is the only true religion."—"The nation," it is added, "protects it by wise and just laws, and forbids the exercise of any other whatever."—The government of the Spanish nation is stated to be "a limited hereditary monarchy."—The power of making laws is vested "in the Cortes, jointly with the King."—In describing the class of Spaniards who enjoy the privileges of citizenship, persons "reputed of African origin, either by the father or the mother's side," are excluded. A similar exclusion is given to Spaniards who obtain naturalization in another country, or who, without leave, absent themselves five years from Spain. The only basis for the number of representatives in the Cortes is *Population*, to be taken from the *census* of 1797, till one more correct can be made. For every seventy thousand souls there is to be one deputy in the Cortes. The returns of the members are made by three successive elections. Every parish appoints electors for the district to which it belongs. These repair to the chief town of the district to choose another set of electors, who, lastly, meeting in the capital of the province, make the final appointment to the Cortes. The Cortes is triennial. No member can be elected for two successive representations. No debate can be carried on in the presence of the king; his ministers may attend and speak, but are not allowed to vote. There is a permanent deputation, or committee of the Cortes, composed of seven members, appointed by the whole body, before a prorogation or dissolution, whose duty is to watch over the executive, and report any infringement of the constitution to the next Cortes. It also belongs to them to convoke an extraordinary Cortes in the cases prescribed by the constitution.

The powers of the Cortes are chiefly these: 1*st*, To move and pass the laws; and to interpret and alter them when necessary. 2*d*, To administer the constitutional oaths to the King, the Prince of Asturias, &c. 3*d*, To determine any doubt or fact relative to the succession. 4*th*, To elect a regency, and define its powers. 5*th*, To make the public recognition of the Prince of Asturias. 6*th*, To appoint guardians to the king while a minor. 7*th*, To approve or reject treaties previous to ratification. 8*th*, To allow or refuse the admission of foreign troops into the kingdom. 9*th*, To decree the creation or suppression of offices in the tribunals established by the constitution, as well as of places of public trust. 10*th*, To fix, every year, by the king's proposal, the land and sea forces. 11*th*, To regulate the military code in all its branches. 12*th*, To fix the expences of the government. 13*th*, To impose taxes, contract loans, and direct every thing relating to the revenue. 14*th*, To establish a plan of public instruction, and direct the education of the Prince of Asturias. 15*th*, To protect the *political* liberty of the press. 16*th*, To enforce the responsibility of the secretaries of state, and other persons in office.

Laws may be proposed, in writing, by any one of the deputies. Two days after the motion, the bill is to be read a second time. It is then determined whether the subject is to be debated, or to be referred to a committee. Four days after the bill has been voted worthy of discussion, it is read a third time, and a day is appointed for the debate. A majority of votes decides the fate of the bill: the members

present on these occasions must exceed the half of their total number by one.

The powers of the king are, 1*st*, To suspend the passing of a law by withholding his sanction. He can exercise this power against any decree of the Cortes, for two consecutive sessions; but is compelled to give his assent if the same law is passed by three Cortes successively. 2*d*, The executive power resides exclusively in the king, and extends to whatever relates to the preservation of public order in the interior, and to the external security of the state, according to the constitution and the laws. The privileges and duties of the executive are thus detailed in the constitution: the King may issue decrees, regulations, and instructions, for the more effectually enforcing of the laws;—it is his duty to watch over the administration of justice;—he declares war, and makes peace, under the control of the Cortes;—he appoints judges to all the civil and criminal courts, on the presentation of the council of state;—all civil and military employments are of the king's appointment;—he presents to all bishopricks, ecclesiastical dignities and benefices which may be in the gift of the crown; all by the advice of the council of state;—the king is the fountain of honour; the army and the navy are at his command, and he has the appointment of generals and admirals;—he has the right of coinage, and the privilege of impressing his bust on the metallic currency of the realm;—the king can propose new laws, or amendments to those in existence.—It belongs also to him to circulate or withhold the Pope's rescripts and bulls;—he can choose and dismiss his own ministers.

The following checks are laid on the king's authority by the constitution:

1*st*, The king cannot prevent the meeting of the Cortes at the periods fixed by the constitution; neither can he dissolve them or disturb their sittings. His advisers and abettors in such attempts are guilty of treason. 2*d*, If the king should quit the kingdom without the consent of the Cortes, he is understood to have abdicated the crown. 3*d*, The king cannot alienate any part of the Spanish territory. 4*th*, He cannot abdicate the crown in favour of his successor without the consent of the Cortes. 5*th*, He cannot enter into any political alliance, or make commercial treaties without the consent of the Cortes. 6*th*, He cannot grant privileges or monopolies. 7*th*, The king cannot disturb any individual in the enjoyment of his property, nor deprive him of his personal liberty. If the interest of the state should require the arrest of any individual by virtue of a royal order, the prisoner must be delivered over to a competent tribunal within eight and forty hours. 8*th*, The king cannot marry without the consent of the Cortes; he is supposed to abdicate the crown by taking a wife against their will.

The Council of State is composed of forty individuals, viz. two bishops, two priests, and four grandees; the other thirty-two must not belong to any of these classes. The members of the Council of State shall be chosen by the king out of a triple list presented to him by the Cortes. The Councillors of State cannot be removed without a trial before the Supreme Court of Justice. Their salary is fixed by the Cortes. The functions of this Council of State are to advise the king on all important matters of government, and especially upon giving or refusing his sanction to the laws, declaring war, or making treaties. The king, besides, cannot bestow any ecclesiastical benefice, or appoint any judge, but at the proposal of the Council of State, who, upon every vacancy, are to confine his choice to one out of three individuals, whose names they are to lay before his majesty.

The laws for the security of personal liberty are these, 1*st*, No Spaniard can be imprisoned without a summary process, wherein he is credibly charged with the infraction of some law which subjects the offender to corporal punishment; 2*d*, The arrest cannot take place without the warrant of a competent judge; 3*d*, Prisoners are not to be examined upon oath; 4*th*, The gaoler shall keep a register of the prisoners, expressing the warrant, and the alleged cause of his confinement.

Such are the main articles of the Spanish Constitution; a production which, considering the circumstances of its appearance, highly deserves the attention of the politician and the philosopher. Spain had been for ages under the most effectual restraints which can be laid on the human mind, to prevent its dwelling upon subjects connected with the authority of civil and ecclesiastical rulers. Few Spaniards, out of the learned professions, devoted any part of their time to reading. The knowledge of the clergy was generally limited to scholastic divinity, as that of the lawyers to the forms of the civil courts. A small proportion of both classes had privately ventured to look beyond the bounds which church and government had set to their speculations, and, books being smuggled from France, an inconsiderable number were become initiated in the principles of the French Philosophical School. The seeds of doubt and dissent, in matters of religion and policy, had greatly spread for the last forty years; but the bulk of the nation was still without a thought on these subjects, and blindly followed the impulse which time and habit had given them. The events which dethroned Charles IV. had no farther broken these habits than merely to show the people how effectually they could oppose their own will to the constituted authorities. But their loyalty was not impaired by their successful efforts. The name of Ferdinand VII. was the great bond of union which preserved the Spaniards from anarchy. To defend the authority of the crown was the only object of their general insurrection; and, having deposited its unbounded powers in the hands of a few, the people retired to their homes, setting no limits to their obedience.

Had not the progress of the French armies dispersed the *Central Junta*, and concentrated the fugitive patriots at Cadiz, it is more than probable that the Cortes would have been assembled according to the ancient forms, and that the privileged classes, supported by the majority of the nation, would have defeated any attempt to alter the old

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constitution. But Cadiz offered to that party, which has been since known by the name of *Liberal*, the most favourable opportunity of striking a deadly blow at the very root of the monarchical power, under which they had so long groaned in hopeless, yet silent, restlessness.

Political Character of Cadiz.

From its maritime position, its commercial interests, and the foreign extraction of many of its inhabitants, Cadiz has, at all times, exhibited a scene of life so different from that which strikes the observer in the interior, that, upon entering its walls, he might imagine himself suddenly transported out of the kingdom. There, instead of the national prejudices in favour of birth, he might perceive the pride of wealth, and an ill disguised impatience of all other claims to respect and influence. If the rich merchants decked themselves with the marks of distinction so eagerly coveted by Spaniards, they still wore them without ease or satisfaction. Apparently raised by these externals to the ranks of the old titled gentry, the new marquis or knight still found himself but little removed above those of his former condition. He could not meet with the hereditary deference which the *Caballero* of the interior found in the labouring classes. Cadiz, in its days of prosperity, had no poor; for, while a stream of wealth was poured in from the American colonies, the sea forbad its population to spread beyond the limits of comfortable subsistence. The line of distinction between the higher and the lower classes was, therefore, less marked than in other large towns of the peninsula; and, when the season of mercantile prosperity was over, as the depression was general, it left the various classes at the same proportionable distance. Cadiz, unknown to herself, cherished, in fact, a republican spirit. The line which divided her rich and her poor, her workmen and their employers, was almost imperceptible when compared with the gulf of prejudice and pride which separated the merchant from the grandee. Thus, undivided by jealousies of rank, and feeling in common that impatience of political superiority which is inherent to the human heart, the people of Cadiz were ready to greet any prospect of change in the monarchical and aristocratical system of the country.

All that was wanting to bring these dispositions into action, and give them a definite aim, was driven into Cadiz by the advance of the French armies within sight of its walls. Madrid had, for a long time, been the resort of the most enlightened Spaniards; the only spot where persons, who had embraced *Liberal* principles, could feel the oppressive yoke of religious tyranny somewhat eased on their necks. As they generally belonged to that numerous class of the Spanish gentry who look up to the patronage of government for the means of subsistence, the court drew them together from the provinces. On the prospect of the political changes which the captivity of Ferdinand opened to the country, these men attached themselves to the *Central Junta*, and finally followed its members in their flight from Seville to Cadiz. Thither, too, flocked all the stragglers of the philosophical party; and, on the dissolution of that dull, dilatory knot of ill assorted men, who, under the veil of dignified gravity, had for a time concealed their unfitness to direct the nation, the Spanish speculatists found themselves in the midst of a population highly disposed to listen to their doctrines, to embrace their views, and constitute them the organs of the new laws which were to remodel the kingdom.

Character and Views of the Framers of the Constitution.

The majority of the first Cortes being composed of the class of men whom, by anticipation, we have called *Liberales*, the project of a Constitution was immediately set on foot, and a committee of the ablest members appointed to draw up the fundamental code of the monarchy. Such a task, at all times arduous, was, in the present circumstances of the country, beset with peculiar difficulties. The legislators, confined within the walls of a town where innovations could not fail to be popular, went through their task under a strong delusion, mistaking their own wishes and the applause of the surrounding multitude for the sense of the nation. Encouraged by the absence of the king, placed beyond any check from the privileged classes, and the weight of the landed property of the country, it is surprising that the framers of the new constitution were not more rash than they appear in the code, of which we have laid an abstract before our readers.

We strongly suspect, however, that the authors of the Spanish constitution were less disposed to consider the real sense of the nation, than to prepare, in their code, the most effectual means of working a radical change in the public mind. Perhaps they despaired of being able, by a more truly Spanish system of laws, to make a lasting reform in the state. Perhaps they feared that, if a portion of the legislative power was deposited in the hands of an upper house, composed of the Grandees and the Clergy, it would clog the motion which they wished to impress upon the almost disorganized machinery of the Spanish state. Perhaps they conceived that the power, which, in the hands of the crown, had been so outrageously abused, could not be reduced too much; and that, since the constitution must recognize a king, he could not be too strictly watched and fettered. We are not, indeed, surprised to find these views in the authors of the Spanish constitution—they were the natural result of their position—right feelings exasperated by a long endurance of tyranny and misrule. But we cannot, on the other hand, give them credit for any degree of that sound and practical wisdom which shone in the English patriots of 1688. The authors of the Spanish constitution had, it is true, to reconstruct the state almost from the foundations. But, professing that they only intended to re-establish the ancient constitution of the kingdom, they had not the ability even to preserve its external form. They certainly neglected all the old materials. Nor have they shown deeper views in the solution of the general problems of politics, such as the *basis* of representation, and the *form* of election. The Spanish legislators have, on both these points, shrunk at the view of difficulties which they wanted either the knowledge or the courage to meet fairly.

On one subject alone the authors of the constitu-

tion yielded to national prejudice without reserve or modification. The article on religion is, unfortunately, an accurate expression of the opinions which the mass of the Spanish nation hold upon that point. Shall we, then, suppose the framers of the constitution sincere in the profession of the strong, undoubting, dictatorial faith, which blazes forth in that notable article? Must we not suspect that exuberance of belief which makes a *Liberal* party stand Catholic sponsors for generations unborn? For our part, we believe it equally impossible that men, whose course of reading and thinking had led them to embrace the political principles which have been enforced in the Spanish constitution, should approve the article in question, as that a nation, still bigoted to such doctrines, should be disposed to receive that constitution. It has been answered, we know, that the political part of the Spanish code was calculated to overturn the law concerning religion. But was it not to be feared that the reverse might happen? Or was it consistent with the wisdom of constitutional legislators to combine the most irreconcileable principles in the fundamental laws of the state? Had they been more temperate and yielding in their political views,—had they not alarmed every Spanish prejudice by their plan of reform, they might have found their religious adversaries less on their guard, and gained some ground on the side of toleration. But the Spanish constitution was like one of those treaties which wily politicians sign with a mutual hope that they contain the elements of destruction to the other contracting party. The *Liberales,* unable to cope with religious prejudice, trusted to the operation of democratic principle; the bigots, cut off from their main body within the walls of Cadiz, clung to their monstrous privilege of keeping the conscience of every Spaniard in bondage. The *Liberales* meant more than they dared to express—the bigots gained all they wanted. Thus, while victory was apparently on the side of the former, the latter held, in the religious intolerance of the country, now raised into a constitutional law, the strongest pledge of a future and more permanent triumph. The events which followed the return of Ferdinand must convince every impartial judge, that the great mass of the Spaniards were not disposed to second the views of the *Liberales;* and that, if the constitution has, at a later period, had influence enough to arm one part of the kingdom in its defence, it owes this support to the injustice and misconduct of the Court faction after the restoration, and not to an original attachment on the part of the people.

Return of Ferdinand VII. from France.

The rapid series of misfortunes which had shaken the imperial throne of France to its foundations opened the way for the return of the captive Ferdinand to Madrid. His appearance on the frontiers would, a short time before, have been hailed by his subjects with general and sincere joy. But an absence of six years, employed by the friends of constitutional liberty in disseminating the principles of political reform, and fomenting a spirit of jealousy against the crown, had now created an active party, who dreaded the appearance of a monarch, born and bred a despot, among a people whose habits were those of implicit obedience. The arrival of the famous Palafox (who, since the taking of Zaragoza, had been a prisoner in France), bearing dispatches from the king to the regency, threw the constitutionalists into great consternation. Ferdinand announced to the regency that he had concluded a treaty with Napoleon, which, in his opinion, "contained no condition that did not accord with the honour, glory, and interests of the Spanish nation; as that country could not have obtained a more advantageous peace after a succession of victories." This implied acknowledgment of successive defeats, this readiness to conciliation with Napoleon, were strong indications of a mind habituated to feelings very different from those which had influenced the Spaniards during the eventful war against the French emperor. Such want of sympathy with those national feelings, which might have been supposed most flattering to any other man in Ferdinand's circumstances, gave little hope of his quiet submission to laws and principles which were plainly intended to reduce his power, and make him the first subject of the kingdom, instead of its absolute sovereign.

The Regency, composed of Cardinal Bourbon (a man, who, though related to the royal family, bore in the weakness of his mind the best security against ambition) and Agár and Ciscár, two naval officers of respectable abilities in their profession, whose only recommendation for that post seems to have been the absence of every qualification which might have given the slightest probability to their election—this Regency beheld with alarm the danger which threatened the system from which they derived their power. The treaty was, of course, rejected, and the attention of the constitutional government anxiously fixed on the means of averting the blow which was already aimed at their authority.

Precautions of the Constitutional Government.

By a decree of the Cortes, the king was suspended from the exercise of all power till he should take the oath which the new constitution prescribed; a route was made out for his journey from the frontiers to Madrid, and an escort directed to watch over him in his progress. The Cardinal, president of the Regency, was to meet his royal relative on the road, under strict injunctions not to perform the usual ceremony of kissing the king's hand. General Copons, the military commander of Catalonia, was made the bearer of copies of the constitution, and of the decree which suspended the royal authority. These he was to deliver into the hands of Ferdinand on the frontiers of the kingdom.

The king entered the Spanish territory on the 24th of March 1814, and followed the route prescribed by the Cortes, till the vicinity of Zaragoza afforded him a pretext for visiting that renowned scene of Spanish patriotism. He soon perceived a general indifference to the constitution among the lower classes; a jealousy of the new men who had risen into importance by means of the late changes; and a revival of those feelings of passive loyalty which the unbounded power of the Spanish monarchs, during so many centuries, had blended with the national character. From Zaragoza, Ferdinand repaired to Valencia, a city well affected to the crown, where

Elío, a royalist general, had the command of a considerable body of troops. Thither flocked many grandees and dignitaries of the church, anxious to inform the king of the favourable turn of public opinion in favour of an absolute monarchy. The cardinal, who, missing the king on the prescribed road, had been obliged to retrace his steps, arrived at Valencia, when a numerous train of royalists, ready to support their master, would have placed a bolder and abler representative of the Cortes in difficulties from which it would be almost impossible for any one to extricate himself with credit. The weak prelate's attempt to follow the directions he had received, added humiliation to the act of homage into which he was awed by the king's frown. His kissing hands, however, did not save him from banishment and deprivation of the two sees of Toledo and Seville, which he held together with the pope's consent.

Revulsion of Feeling in the Nation.

The progress which the constitutional principles had made was so slight, and the new political system had lately lost so much among people otherwise inclined to a reform in the state, that it was easy to foresee a revulsion of feeling in which the great mass, which had hitherto been nearly passive, would give the court party an irresistible preponderance. Ferdinand's advisers were sufficiently quick-sighted to seize the favourable moment. Elío, in the name of his military division, presented a memorial to the king, in which he was entreated to govern in the manner of his ancestors. A petition, signed by sixty-nine members of the sitting Cortes, reached the king, about this time, describing that body as a mere tool in the hands of a republican party, without freedom of debate, and acting under the control of a mob regularly hired to take possession of the galleries.

A more favourable opportunity has seldom presented itself to any monarch for consolidating the privileges of his crown, while he promoted the happiness of his people, than that which the circumstances of Spain offered to Ferdinand at this moment. The feeble roots, which the new political principles had struck in the nation, were just kept alive by a recollection of the ruinous follies of the preceding reign. The slightest security against the recurrence of similar excesses, granted by the throne to the people, would have deprived the *Liberal* party of the remnant of their influence. With his own party, the king was still absolute; and his will would have been obeyed without the least attempt at evasion or resistance. Ferdinand might have confirmed the abolition of the Inquisition, and the existence of the Cortes. He might have established a Chamber of Peers, and raised the grandees, by that means, from a state of moral and intellectual degradation, which renders them worse than a useless burden to the state. A few reforms in the internal administration of the kingdom might, if proceeding from the crown, have enabled Spain to rise gradually, and without convulsions, from her former languor into a state of convalescence; during which, life and energy would, in due proportions, diffuse themselves through the whole body. But unfortunate Spain was doomed to suffer from the same cause, which, in our opinion, threatens Europe with a long series of bloody struggles between the people and their rulers. The popular leaders aimed at the possession of paramount power, while nothing but uncontrolled authority would satisfy the crown.

Resumption of Absolute Power by the King.

On the 4th of May 1814, a decree was solemnly promulgated, in which the Cortes were declared illegal, and all their laws consequently rescinded. The spirit of the worst times of the Spanish monarchy seemed to have dictated this first act of the restored Ferdinand—that king for whom Spaniards of all classes, opinions, and denominations, had been lavish of their blood. Having thus announced his intention to wipe off the memory of constitutional freedom, he set off for the capital, preceded by a division of Elío's army, under the command of General Eguía. These troops found no resistance either on their way to Madrid, or upon entering that town. The people, on the contrary, seemed generally disposed to greet the approach of the absolute king. The Cortes, thus despised and neglected by the majority of the Spaniards, and internally cankered by the presence of a strong party, who had constantly aimed at the destruction of the system which they had sworn to support, were instantly dispersed by the soldiers. The arrest of the two inferior regents, Agár and Císcar, and of the president and secretary of the Cortes, which took place on the nights of the 10th and 11th, seem to have been considered as preparatory steps to the reappearance of Ferdinand in the capital.

Demonstrations of Joy in different parts of Spain.

The news of these events had scarcely reached the chief towns in the provinces, when the mob, headed by their usual leaders, the priests, broke out into fierce demonstrations of joy, calling for the instant restoration of the Inquisition, and hastening to demolish the lapidary inscriptions, which the Cortes, from the vanity of displaying their triumph over their opponents, had caused to be erected in every town and village. It is fortunate, indeed, that no bloody scenes followed this reaction of a long suppressed popular feeling; though a desperate attempt was made at Corunna against the most active members of the Liberal party in that town, who had been previously committed to prison.

Spirit of Revenge displayed by the Court.

Had Ferdinand and his advisers allowed their judgment to prevail over their resentment, they would have readily perceived that their future security was not consistent with the habits of insubordination which the Spanish mob was so rapidly acquiring; and that leniency and forgiveness were the most effectual means of thinning the ranks of their enemies. The court party, however, showed a fixed determination of allowing full sway to their revengeful spirit. The arrest of between thirty and forty deputies of the late Cortes, attended with seizure of papers and sequestration of property, was decreed by the king, who appointed a commission of three judges, two of whom had been fellow-deputies of the prisoners, to collect evidence against them. By another order, the members who had subscribed the above-mentioned petition for the repeal of the constitution, were invited to criminate the *Liberal* deputies for their conduct and opinions during the last session.

In the course of this persecution not one was spared who had, directly or indirectly, contributed to the establishment of the constitutional system. The number of state prisoners was increased in the month of June, by the arrest of forty-five individuals, formerly members of the Cadiz Cortes, and literary men of eminent talents, who had assisted the popular government with their pen. The trial of the prisoners, if such a name can be given to judicial proceedings, which precluded all chance of acquittal, was conducted with more than Spanish dilatoriness. Three sets of judges were successively appointed and removed; till the king, impatient of further delays, ordered a list of the prisoners to be laid before him; and in a decree of the 15th of December 1815, each of the names (about seventy in number) appeared before the public, bearing the sentence which Ferdinand, in his own writing, had affixed to them. We shall give the following by way of specimens. Count Toréno, Mina, and Florez de Estrada, who had evaded pursuit, and fled the country, were condemned to death. Arguelles, who may be considered the author of the constitution, was sentenced to eight years' exile at Ceuta, on the coast of Africa. Canga Arguelles was confined to the fortress of Peñíscola, in Catalonia, for an equal period. The same length of confinement was assigned to Martínez de la Rosa, and to Calatráva, two distinguished members of the Cortes. The four ecclesiastics, Villanueva, Muñóz-Torrero, Olivéros, and Cepéro, were sentenced to six years' imprisonment in different convents, and to the loss of their benefices. A'lvarez-Guerra and García-Herreros, who were ministers to the Regency on Ferdinand's return, and Generals Valdés, O'Donoghue, and Villacampa, who had evinced a firm attachment to the new system, were to be imprisoned for periods of eight, six, and four years. Quintana, one of the first ornaments of modern Spanish literature, who, probably from his great moderation, and love of studious retirement, had never been elected a member of the Cortes, was sentenced to be imprisoned six years in the fortress of Pamplona. Strict orders were issued to deprive the prisoners of all communication, and not to be allowed pen and ink. The persons contained in the list, who had not escaped, were seized in the night of the 17th December, and subsequently removed to their destinations.

It was not more safe to be admitted to Ferdinand's confidence than to side with the enemies of his arbitrary power. Macanáz, his confidant, in France, was arrested, the same night, by the king in person. Escóiquiz, Ferdinand's tutor, and one of his companions in exile, was, at this period, disgraced and removed to Zaragoza. The Duke of San Carlos, another of the king's adherents in his misfortunes, was dismissed from the ministry.

The court party having gratified their spite, wished now to secure the support of the clergy, whom the Liberals had offended. By a royal order of the 20th of May 1814, all purchasers of church property were compelled to restore it, without receiving compensation. The Inquisition was regularly re-installed, and urged to exert its powers against all persons suspected of *Liberal* opinions. A bull was obtained from the Pope for the restoration of the Jesuits in Spain. Monks and bigots were the sole directors of the king's conscience. Conceiving that the times when Spanish monarchs could trample down their subjects, without being disturbed by a single murmur, had returned, he publicly declared himself "not accountable to any, except God and his confessor," and thus proclaimed his will to be the law.

Progress of Discontent against Ferdinand.

The convulsions, however, which had agitated the kingdom, could not but have roused the dormant energy of such spirited people as the Spaniards. The novelty, it is true, of the political doctrines which the Cortes had sanctioned; the disturbance which the new order of things had given to the national habits; the doubtful, or still unperceived advantages of the *Liberal* institutions; the jealousy which is always created by the sudden elevation of new men; —such were the main sources of the dissatisfaction with the Cortes, which restored despotic power to the hands of Ferdinand. But a fresh disappointment awaited the fond hopes of the people. Ferdinand could not recal the languid repose of former days. The spell of custom, which bound the nation together, with the ties of mere form, and made the strength of millions shrink before the shadow of power, had been broken for ever. The court, besides, had found the treasury doubly drained, from the effects of former extravagance, and the demands of the late war. Bribery and venality were soon seen to prevail round the throne, to a greater extent than in the time of Godoy. The army, who had been hitherto amused with promises of regular pay and promotion, began to groan under want and neglect. Officers of high rank appeared about the streets in the night imploring the charity of their fellow countrymen. The armed bands, or *Guerillas*, who had assisted in the defeat of the French, having now nothing to expect from Ferdinand, and being unfit to resume habits of industrious labour, became regular and organized banditti. Melchor, the leader of a numerous band, infested the whole of Extremadura, for a considerable time, setting the helpless magistrates at defiance, and committing all sorts of atrocities.

A government so unable to gratify the ambition of its adherents, and so incapable of affording protection to the people, could not employ restrictive measures without hastening its own destruction. In vain did the court party silence the press, or bribe it into their service. Facts, which crowded before the eyes of the public, and addressed themselves to their feelings, pleaded, daily, the cause of liberty, in the most powerful language.

Secret Societies.

Many of the Spanish officers, who were prisoners in France, had become *Free-Masons* in that country, and numerous lodges were established in Spain, during the occupation by Napoleon's armies. Masonry had at all times been held in the utmost abhorrence by the church and government, and both had employed their respective weapons to deter their subjects from its mysteries. Finding now that the evil they dreaded had found its way into the country, nothing was left untried in order to check its progress. A fresh sentence of excommunication was

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obtained from the Pope against Free-Masons. The Inquisition traced out, in every province, the officers who had been initiated in France, as well as the members of the Spanish lodges. Fortunately, they were too numerous to be punished with all the rigour of the law. But the imprisonment of some, and the fears of all, were sufficient to prevent the Spanish Masons from acting collectively.

Comuneros.

It was, however, about this time, we believe, that another kind of secret societies, exclusively political, were formed in Spain. The members assumed the name of *Comuneros,* to denote that they met in the spirit of Padilla and his followers, who, under the same appellation, rose against the encroaching despotism of Charles V.* An extensive correspondence was established between the associates in the different provinces, who, acting in concert, and according to a fixed plan, were ready to seize the first opportunity of restoring the constitution.

Public burning of the Constitution.

Though we account it a signal misfortune that Spanish patriotism had not a less objectionable rallying point than the Code of the Cadiz Cortes, yet it is probable that, but for the existence of such a definite object for which to contend, the enemies of despotism would not have been able to combine their efforts. Men possessed of more talents than the purblind crew who surrounded the throne would have easily seen the necessity of setting up some rival Charter; any thing in the shape of a Fundamental Law, which might divide the public opinion, and divert it from a constitution which had been conceived in a spirit of violent hostility to the crown. But Ferdinand's counsellors took the course which was most apt to raise the new code in the estimation of the country. As many copies as could be obtained at Madrid were heaped on a cart, together with the journals of the Cortes. The guilty volumes were thus conducted, with ludicrous solemnity, to one of the public squares, and there committed to the flames by the hands of the hangman. This contemptible triumph was closed with a solemn *Te Deum* in the collegiate church of the capital.

The effect of prohibitions and *autos da fe* against books is well known; it gives them reputation in all countries; how much more among a people whose eyes were just opening to a perception of the intellectual thraldom in which they had been kept by similar means;—a country, where the notion that the merit of a work should be judged by the anathemas it lay under, was making a rapid progress?

The constitution of the Cortes, though ill suited to the institutions, habits, and feelings of the bulk of the Spanish nation, is a manual of popular principles, which might, under any circumstances, bring constant accessions of strength to the Liberal party. A train of reasoning, however powerful, upon the rights of the people, would make but a slight impression in a country where close and industrious reading is scarcely known. But the effect of a small volume, containing the abstract principles of democracy disguised under monarchical forms, and reduced to practical laws or simple declarations, would engage the attention of thousands; for the shallowest and most undisciplined mind will readily catch the notion of sovereignty inherent in the people; and, in proportion to the want of deep views on the complicated machinery of human society, will be the self-complacency of the young politician, who imagines he has obtained a clue to every problem of government.

Progress of Discontent.

The effects of the new Constitution, considered as a political pamphlet, could only be checked by the dignified and judicious conduct of a court supported by the most respectable classes. But Ferdinand was surrounded by a medley of cowled courtiers, intriguing priests, and old placemen, all poor, and all ambitious. The king himself had much to ask for, and but little to give, save empty titles. The army, who had now learnt their irresistible weight in political changes, became dissatisfied and restless under a state of things which doomed them to neglect and poverty. The inferior gentry, of which a great portion depend on court favour for places, saw, with dismay, that while the late reform had swept away many of the situations under government, such as remained were reserved for those only who had never wavered in their allegiance to monarchical despotism. The young men, lastly, of the middle classes, who, during the existence of the Cortes, had had a taste of the agreeable excitement of a popular system, could not brook the death-like apathy which followed the restoration.

Activity of the Secret Societies.

The malcontents, though numerous, and constantly augmenting, would have found it difficult to communicate with each other, to calculate their strength, and direct it with skill, if the secret societies had not created among them something like the union and activity which, in free states, are the effects of a well-regulated party. In spite of the Inquisition and its emissaries, the *Comuneros* held meetings in most of the head towns, and kept up an active correspondence among their lodges. Cadiz, whose political temper has been described already, was, it seems, the head-quarters of the conspirators. They could not have fixed upon a more advantageous position; for, besides the opportunities which its numerous and changing garrison constantly afforded of tampering with the officers, some wealthy merchants of that place had devoted their fortunes to the restoration of liberty.

General Morillo practised upon by the Patriots.

Cadiz and its neighbourhood had been made the rendezvous of the troops which, under the command of General Morillo, were ordered by Ferdinand's government against the revolted provinces of South America.† It being now agreed among the *Liberals* that the intended revolution should be effected

* *Vide* Robertson's *Charles V.*

† The unyielding and illiberal spirit of the Cortes in regard to the Colonies was closely followed by the king's government on his resumption of absolute power. It is a curious circumstance that the *Liberal* party, who, by their obstinate refusal of the demands of the Colonies, urged them into open rebellion, should

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by the army, the presence of a strong military division reluctantly engaging in a dangerous service beyond the seas, must have greatly raised their hopes and increased their activity. Morillo's loyalty was tried, and he seemed for a time to waver between the obvious duties of his station and the suspicious call of revolutionary patriotism.* It is said that the General was found, at first, ready to listen to the offers of the patriots; and if it be true that he subsequently thought it necessary to make a spontaneous confession before the Inquisition, he must have been present at some masonic meetings;—a crime from which, we believe, none but the members of that tribunal could give absolution at that period. By what precautions of the patriots, or what subterfuge of Morillo (who, though shrinking from the proposed rebellion, might yet be unwilling to break for ever with a determined and fast growing faction), the effects of such a recantation were not felt by the lodges, we are not told, and cannot conjecture. It is a fact, however, that Morillo embarked with his troops while the secret societies continued their labours unmolested.

Porlier's Attempt and Failure in Galicia.

Galicia was one of the provinces to which the Cadiz patriots had extended their secret influence. Don Juan Diez Porlier, an officer who had distinguished himself against the French, was at this time confined, under suspicion of disaffection, to the Castle of San Antón, near Corunna. His health being impaired after a year's imprisonment, he obtained leave to proceed under an escort to a watering-place in the neighbourhood. The officer, to whom the prisoner was given in charge, was a member of the secret societies, in correspondence with the head lodge at Cadiz. He soon put Porlier in possession of the plans for a military insurrection which were then under discussion among the patriots, and earnestly urged him to strike the first blow in the province of Galicia. Many officers in garrison at Corunna and Ferrol offered also their services to Porlier, who, miscalculating his means, and judging of public feeling from that which prevailed among his friends, was not long in accepting the dangerous command to which he was invited. Attended by the officer, whose duty it was to prevent his escape, and the twelve soldiers commanded by that officer, Porlier entered the city of Corunna, about midnight of the 18th September 1815, and was soon joined by most of the troops in that town. Supported by his associates, he arrested the governor and the principal supporters of the *Servile* party. The imprisoned Liberals were set free, and such proclamations as are usual on these occasions were posted about the town. The oath to the constitution of 1812 was repeated, and a detachment of 800 men was ordered to march on Ferrol, where the garrison, it was said, only awaited the presence of Porlier to declare in favour of the constitutional system. But the royalist party had been actively employed in that town since the arrival of the news from Corunna. Emissaries were sent to mix with Porlier's troops on their march. They found him with his detachment at the village of O'rdenes, where the troops were to pass the night. The non-commissioned officers were soon gained over, and the men yielded to the first suggestion of making their peace with the king's government by the seizure of their leader. Porlier and some of his officers were at supper when the soldiers surrounded the house. The officers, it should seem, were able to escape; but the General, being obliged to surrender, was executed at Corunna, on the 3d of October. Porlier met his fate with the dignity and composure of a man who feels conscious of the justice of his cause and the purity of his intentions. Had that unhappy officer possessed means to keep his ground till Cadiz, Barcelona, Valencia, and Zaragoza, had declared themselves, the revolution would have been complete, as it happened at a subsequent period.

Lacy's Attempt in Catalonia.

Our limits do not permit us to mention the numerous conspiracies which were discovered and quelled after the death of Porlier. But we cannot omit a brief account of the unfortunate attempt made by General Lacy in Catalonia, where, during the latter part of the war against France, he had commanded the Spanish army against the invaders. As a reward for his services, Lacy had been appointed Captain-General of Galicia; but being suspected by Ferdinand's government, he was removed to Catalonia, and confined within the limits of a certain district. In the spring of 1817, Lacy obtained leave to visit the mineral waters of Caldetes, near Barcelona. He there met with several discontented officers, with whom he planned an insurrection. It was expected that all the garrisons of Catalonia would mutiny on the 5th of April, a day on which Lacy was to raise the standard of rebellion by the assistance of the regiment of Tarragona, which was stationed at a short distance. Two companies had been gained over by the lieutenant-colonel, when the whole plan was disclosed to the colonel by two subalterns in Lacy's confidence. The colonel appealed to the loyalty of the yet undebauched part of the regiment, and he was answered by a display of zeal in the royal cause. The two revolted companies joined Lacy, who, perceiving no other movements in his favour, began a march to Mataró, proposing to raise the peasantry, or to escape into France if he failed of support. The peasants appearing everywhere either

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have virtually sanctioned the separation, by stopping the reinforcements which might have given a chance of success to the Spaniards. For an account of the war of independence in Spanish America, see the Articles New Granada, Mexico, and Buenos Ayres.

* We relate this and similar facts on the authority of Mr Blaquiere's *Historical Review of the Spanish Revolution*, which we have followed in the narrative of that period. From our personal knowledge of Spain, we have considered ourselves entitled to use our own judgment in rejecting some circumstances which seem to have been admitted into that work from the author's honest but excessive confidence in some of his Spanish authorities.

hostile or indifferent, the soldiers were disheartened, and fell off to a man. Lacy took shelter in a cottage; but was soon betrayed and taken. It was not deemed safe by the government to execute the sentence of death which a court-martial pronounced against him, within the walls of Barcelona, where a strong feeling of compassion had shown itself towards the unfortunate Lacy. It was, therefore, reported that the king had commuted the sentence into that of imprisonment for life in the fortress of Majorca. Lacy's removal took place under that impression. He was cruelly undeceived, on his arrival, and desired to prepare for death within a few hours. Lacy was shot in the ditch of the castle at five o'clock in the morning of the 4th July 1817.

Successful Revolution near Cadiz.

From the character of these attempts, and the temper manifested by the bulk of the people, a dispassionate observer will readily adopt the conclusion, that the endeavours of the patriots depended for success on some happy combination of circumstances, which, by once disconcerting the weak government of Ferdinand, and making him yield even for a moment, would give an impulse to that impassive mass who had hitherto beheld the contest unwilling to share its dangers. For it is clear, that a great majority of the nation, though determined not to make or modify a government for themselves, would readily submit to any political system which might happen to obtain the ascendancy. The chances were, therefore, in favour of the active party, who, though so often defeated, had still sufficient courage and perseverance to renew their attacks on a dull enemy, who adhered, from ignorance and weakness, to a plan of defensive warfare.

Intended Expedition to reinforce the Royalists in South America.

It was not long before the erroneous policy of the court of Madrid, in regard to the revolted colonies, presented to its enemies at home the means of re-establishing the constitution, and making their party paramount in the state. Instead of paying the arrears of the army, the only body of men which could effect a revolution, the blind obstinacy of Ferdinand and his advisers employed all the money they had been able to collect, in fitting up a second expedition, which was to reinforce the Royalists at Venezuela. The troops which were to embark in the autumn of 1819 had been collecting in Andalusia, then governed by Henry O'Donnell, Count of Abisbal, whose assistance in the restoration of arbitrary power had been rewarded with the military command of that province. The expeditionary army was, consequently, under his command till it should sail from Cadiz, and the various corps had been quartered at no great distance from that residence of the Captain-General.

It will be readily admitted, that a more favourable opportunity could hardly offer itself to the Patriots than the presence of a military division, whose officers were favourably inclined to their cause, and where a general dislike of the service, for which it was intended, was prevalent. The prospect appeared the more favourable as it was credibly reported, that O'Donnell, wishing to atone for the mischief he had done by an excess of loyalty, had volunteered to be the leader of the insurrection. The report was, indeed, well-founded. The Captain-General himself had fixed a day for proclaiming the constitution, and meetings had been held at his residence for the organization of a temporary government. Some offence, it seems, had been given him at one of these conferences, by the determination of separating the civil from the military command, when the revolutionary government should be established. He had continued, nevertheless, at the head of the conspiracy, and even urged the necessity of anticipating discovery by striking the blow on the 8th, instead of the 15th of July. On the 7th, O'Donnell repaired to Port St Mary's, where all the infantry had been collected by his orders. Sarsfield, his second in command, was to join them, the next morning, in the plain of Palmár, with the cavalry which was quartered at Xerez.

Soon after sunrise, on the 8th, the infantry was drawn up in the place of their rendezvous. The officers who were in the secret could hardly refrain from breaking it to the troops under their command; yet waited with impatience the arrival of the cavalry, and the presence of their general. Both were at length seen at a distance, and approaching in opposite directions. O'Donnell, with his staff, and Sarsfield at the head of the horse, came up at the same moment. But, instead of the expected signal, the cries of *Viva el Rey*, which were raised by the cavalry as they galloped along the line, were instantly re-echoed by the infantry. The deluded conspirators were immediately called in front of the troops, and Abisbal himself gave the necessary orders for their removal under an escort, to some of the neighbouring fortresses.

The duplicity of Abisbal had rendered such an effectual service to the cause of despotism, and the repeated defeats of the *Liberal* party had so clearly shown the difficulty of giving an impulse to the lower classes in its favour, that it is quite surprising to find a complete revolution effected within a few months of the event we have related. But the court party were not stupid enough to mistake Abisbal's conduct for pure unalloyed devotion to the crown; nor yet sufficiently politic to secure his services to the king by such rewards as might satisfy his ambition, and make him seal, by his subsequent conduct, the well-merited distrust and hatred to which he was exposed among the Patriots. He was removed from the command of the expeditionary troops, and a man scarcely known by his title of Count Calderon, and much less by any talents displayed in the service, appointed to succeed him.

Final Success of the *Liberales*.

The reappearance of the yellow-fever at Cadiz, soon after the imprisonment of the patriot officers at Palmár, obliged the government to remove the troops to more healthy spots, at some distance. Arcos was made the head-quarters; the rest of the army was divided between Las Cabezas de San Juan, to the north of that town, and Alcalá de los Gazúles, in the opposite direction. This was considered a favourable opportunity for carrying into execution the same plan which had failed through the treachery of O'Donnell. The members of the secret societies, at Cadiz, engaged to procure the escape of the prisoners, one of whom, Quiroga, had been appointed to be the commander-in-chief of the revolt-

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ed army. Riego was, in the meantime, to be placed at the head of the insurrection.

The 1st of January 1820, being fixed upon, the soldiers were gradually gained over by means of the gold with which the officers were supplied from Cadiz. On the morning of that day, Riego drew out the battalion of Asturias, of which he had a temporary command, and having proclaimed the constitution, began his march towards Arcos, where, by the assistance of part of the officers in that town, he intended to seize the general-in-chief. Quiroga, who, it was expected, would be at liberty, by that time, was to march with the forces stationed at Alcalá, to the Isla, and from thence to the gates of Cadiz, which, if he could reach before the news of the insurrection, would be thrown open by some officers of the garrison, now enrolled in the bands of the insurgents. Riego, though arriving at Arcos much later than he had expected, effected the arrest of Calderon, with scarcely any difficulty. Quiroga, being much longer detained in his march, could only take possession of La Isla. Riego advanced to Xerez, thence to Port St Mary's, and finally joined Quiroga. The strength of the patriots was about five thousand men, unsupported by either artillery or cavalry.

The period which followed this junction is one which throws considerable light on the state of the public mind in Spain, and shows the difficulty, which we have pointed out already, of giving an impulse to the great mass, who, influenced by inveterate habits, will take no side in these political struggles.

Riego's March to spread the Insurrection.

Five and twenty days had elapsed since the proclamation of the constitution at Las Cabezas, without the revolution making any visible progress. A paper warfare was carried on by the leaders at the Isla, and the authorities at Cadiz; but the patriots were left to their own resources within a very limited spot, while troops were collecting about them, and the activity of the loyalists at Cadiz precluded all hope of assistance from the revolutionists who were within the walls. To rouse the spirit of the country, and spread the flame of the insurrection, Riego proposed to lead a flying column of 1500 men, in such direction as circumstances would allow. Followed by a division of the royalists, who seemed more determined to harass him than to fight, he successively proclaimed the constitution at Chiclána, Coníl, Vejér, and Algeciras. Though ordered by Quiroga to march back to the Isla, Riego found it necessary to proceed in the only direction which the royalists had left him. In this situation, however, he spent three days at Vejer, in public balls and banquets, where officers and privates mixed indiscriminately with the town's people. From thence the flying column advanced to Malaga, closely pursued by the enemy. Meeting with no support from the inhabitants, Riego proceeded to Antequera. Harassed by incessant marches, and having sometimes to fight their way through detachments of the enemy's forces, Riego took the determination to push, with the remnant of his force, now reduced, by desertion, to about 300 men, into the fastnesses of Sierra Morena, where they eluded further pursuit by dispersion.

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Insurrections in different parts of Spain.

The patriots of the Isla had seen three long months elapse without any prospect of support from their countrymen, and trusting merely on the efforts of the secret societies, which had hitherto appeared unavailing. Mina had, however, entered the valley of Bastán, in Navarre, on the 25th of February. He had been, long before, obliged to fly into France in consequence of a fruitless attempt to overturn the government of Ferdinand, and now he hastened to lend his assistance to the patriots. He found a numerous band ready to follow his standard.

The garrison of Corunna, headed by Don Carlos Espinosa, a colonel of artillery, had risen, about the same time, against the Captain-General of Galicia, and proclaimed the constitution throughout the whole province. Similar movements took place on the first days of March at Zaragoza, Carthagena, Valencia, Murcia, and Granada.

Ferdinand accepts the Constitution.

These insurrections, though partial, could not but appal the weak, ignorant, and unpopular party, which surrounded the throne. Had Ferdinand been able to depend on the loyalty of an able general, he still would have found fidelity among the soldiers, and a great part of the officers. It was, however, an expiring feeling which, in the present circumstances of the country, a mere breath could extinguish. Should the general, to whom the command of a central army, which was to be formed in La Mancha, be inclined to betray his charge, the king himself would be obliged, by the constitutionalists of the capital, to save his life by the assumption of their badge, and surrender, at once, at discretion.

Abisbal was still at Madrid; and his late important service gave hopes that he would be faithful to the king, for whose sake he had sacrificed the honour he had pledged to the patriots. It was considered improbable that he would change a fourth time in his politics; and he was, accordingly, invested with the command of the army of La Mancha. But, before he quitted Madrid, on the 3d of March, he had plotted with the colonels and superior officers of the garrison, engaging to declare for the constitution as soon as he should reach Ocaña, where one of his brothers commanded a battalion of infantry. True to this last engagement, Abisbal proclaimed the constitutional system, the day after he had quitted the court. He established a communication with the patriots of La Isla, and left the final completion of the revolution to his reconciled friends, the liberals of Madrid.

The account of the military insurrection at Ocaña did not fail to produce the effect which had been prepared by the constitutionalists of the capital. An immense crowd surrounded the royal palace, who called on Ferdinand to accept the constitution. Things had now come to a point where there was no room for deliberation. The king appeared at the balcony holding a copy of the constitution in his hand, as a pledge of his readiness to swear observance to its laws. As, according to that code, the monarch cannot exercise his portion of authority till he has taken the oath therein prescribed, a committee of government was installed, who should convoke the Cortes, in whose presence alone the king can perform those acts which put him in full possession of his constitutional rights.

The Inquisition is abolished, and the State Prisoners set free.

Whatever may be the merits of the political system which the success of the Spanish *Liberales* restored,—whatever the censure which competent and dispassionate judges may pass on the means which ensured their success,—there is something so glorious in the first results of the change, that, for a moment at least, the heart must give itself up to mere feeling, and oblige reflection to shrink and be silent. The instant dispersion of that abominable tribunal, the Inquisition, and the liberation of the state prisoners, whom Ferdinand allowed to linger in confinement, were acts which might ennoble a worse cause than that of the Spanish Liberals. They were performed without delay, and, as far as circumstances permitted, by the hands of the mob—a dangerous instrument indeed, which can never be employed without mischief; but which would lose much of its destructive character if it were only used, as the last resource, in the defence of humanity.

Massacre at Cadiz.

As it has been our study so to perform this rapid sketch, as to put the reader in possession of such facts as may enable him to understand the principles and temper of the two great parties which contend for political power in Spain, we cannot omit the bloody and disgraceful scene which took place at Cadiz on the 10th of March, the day which had been appointed to proclaim the constitution.

The accounts from Madrid had dashed the hopes, with which the unfavourable circumstances of the constitutional troops of La Isla, had flattered the Andalusian royalists. Urged by a blind and ferocious spirit of revenge—perhaps encouraged by some dark hints from persons who could effectually screen them—the partizans of absolute monarchy contrived a plot, of which the absurdity is hardly exceeded by its barbarity.

The Captain-General Freyre, on the receipt of dispatches announcing the King's acceptance of the Constitution, repaired to Cadiz from Port St Mary's, in the afternoon of the 9th of March. The impatience of the triumphant party to have the Constitution proclaimed, scarcely allowed him to postpone that ceremony till the next morning. But a desire that the chiefs of the patriotic army, whom he had invited, should be present, was a sufficient reason to check the eagerness of the people. Quiroga, the patriot general, was, however, too well acquainted with the temper and dispositions of his enemies, to acquiesce in the demand that he should disband his troops, and allow the unarmed soldiers to mix with the citizens, at the ensuing solemnity. Four officers alone, preceded by a flag of truce, were sent to witness the proclamation. Being admitted to the presence of the Captain-General, the evident uneasiness under which they perceived him labouring, and some expressions indicating a degree of anxiety for their safety, had just begun to raise their fears, when the report of musquetry, mixed with the cries of the suffering, or affrighted multitude, suddenly changed suspicion into the most appalling certainty. Freyre hastened out of the house, without providing for the safety of the deputies, who yet were so fortunate as to find the means of escaping the fury of their enemies.

In the mean time, the most atrocious massacre was taking place in the streets, and in the principal square of Cadiz, where the people had assembled to witness the proclamation. The instruments of this barbarous deed were the privates and non-commissioned officers of two battalions of infantry, called the *Guides*, and the *Loyalists of Ferdinand the Seventh.* Instigated, as it is believed, by the governor of the town, and the chiefs of the royalist party, the soldiers had engaged to disperse the multitude, and prevent the intended ceremony. Large quantities of wine and spirits had been sent to the barracks, so that the men were in a state bordering upon intoxication, when they broke out with their arms. From the moment these monsters were loosed, they continued firing, indiscriminately, upon the people, till their ammunition was exhausted. About five hundred persons, men, women, and children, were seen in the streets of Cadiz, dead, dying, or wounded, before the authorities of the place had taken any measure to stop the massacre. Some officers of the Andalusian militia, not on duty, ran, of their own accord, to their barracks, and, drawing up in great haste, part of the men sallied forth into the streets, where they exercised themselves, with the utmost zeal, in protecting the lives of the defenceless citizens, and giving help to the wounded. The author of this article feels the greater satisfaction in recording this act of courage and humanity, as he believes it passed unnoticed, probably because the Andalusian militia had, to the last, remained in the royalist army. He received, at the time, an account of the whole transaction from an eye-witness of unimpeachable veracity. In the evening of the same day, the soldiers who had been employed in the massacre, were marched out of Cadiz. The deputies from the patriotic army, coming forward from their places of concealment, surrendered themselves into the hands of the Captain-General, who, still hoping some favourable turn in the affairs of the royalists, confined them within the Castle of Saint Sebastian. Indeed, so blindly confident were the leaders of that party that the insurrection would yet be quelled, as to have ventured on giving public thanks to the assassins. But the next dispatches from Madrid put an end to their hopes. The deputies were set at liberty. Both Freyre, the Captain-General, and Campana, the governor of Cadiz, were arrested, to take their trial. That trial was, however, delayed till public indignation died away; and we have not heard of any punishment inflicted on the criminals.

Re-Assembly, Character, and Aims of the Cortes.

The Constitutional System being now completely restored, and in action, the Cortes assembled at Madrid in June 1820, and the King took his solemn oath, before them, on the 9th of the following month.

We might here conclude this article, leaving the task of describing the events of this new era to those who, free from the mists which always envelope and distort the passing transactions of political revolutions, would be able to record them without the danger of being misled by their own prejudices, or the misrepresentations of parties. But we feel that we should not do justice to our readers, did we con-

clude without attempting a brief sketch of the character and temper of the Government of the Cortes, their chief aims in the reform of the country, and the obstacles which have hitherto opposed their system.

The Cortes Extraordinary, which were convened on the restoration of the constitution, contained most of the patriots who had suffered during the arbitrary reign of Ferdinand—the original contrivers and supporters of the constitution. This was a measure which the military reformers of the Isla could not, and, probably, were not disposed, at that time, to oppose. But the seeds of jealousy between the two parties, the contending claims of the liberators, and those they had set free, could not remain dormant and inactive. The *Islà Patriots* naturally aspired to the first places and influence in the state: the *Old Liberals* soon felt their own dependence and inferiority. The *Secret Societies* were now more active than ever, and a rivalship between the *Free-Masons* and the *Comuneros* grew out of the different principles adopted by each of these parties, who, in their character and views, might be compared to the Old Whigs and the Radical Reformers in England. The *Free-Masons*, however, soon found themselves defeated; and those who had been forced upon Ferdinand, as his Ministers, were displaced to make room for the friends of the Revolutionary army.

The Cortes, though elected under the influence of the triumphant party, and acting under the direction of the popular leaders and their emissaries, who were regularly stationed in the galleries of the House, exhibited a degree of moderation which does honour to the national character. The measures of retaliation were limited, and infinitely less severe than those in which the king's friends had indulged. Even the most violent democrats, those who had placed themselves at the head of the populace, were satisfied, for a time, with the awe into which the Revolution had thrown their opponents. But the numerous conspiracies, subsequently discovered, increasing the fears of the new patriots, a deed of horror was perpetrated at Madrid, on the person of a dignified priest, which, from the perfect indifference shown, upon the occasion, by the existing authorities, we strongly suspect to have been planned by the secret societies. It was indeed evident, since that period, that nothing was done but through their influence in Spain.

Few of these atrocities were needed in that country to paralyze into perfect passiveness a great part of the population, especially among the middle and higher classes, and to revive those habits of silent submission to " the powers that be," which a tyranny of ages had confirmed. Had it been in the power of the new government to establish themselves without encroaching upon the rights of the church, and, thereby, confirming the suspicions of infidelity, under which all denominations of *Liberals* have long lain among the Spaniards, the resistance to the new order of things would have been limited, at least for a time, to a very inconsiderable and powerless minority of the nation. But, unfortunately for the interests of freedom in Spain, the old political system is too intimately blended with the strongest religious prejudices of the country.

To steer clear of this rock exceeded the powers of human wisdom. The Cortes *Extraordinary*, as well as the *Ordinary*, which succeeded them, contained a large proportion of the talent, though scarcely any of the rank and property, of the country. Most of the clergymen, and perhaps all the lawyers, who had obtained seats, belonged to that class of Spaniards, who, free from religious prejudices, but having no system of their own to support upon these points, would shrink from an open contest with the zealots, without, however, letting pass any opportunity of showing their spite, by a side-blow. The pecuniary wants of the government; the desire of gaining partizans to the constitutional system by the transfer of property, exclusively under its sanction; together with the opportunity which the existing circumstances presented, of indulging the secret, though strong, feelings of aversion to the national system of religion, which rankle in the bosom of every liberal Spaniard, betrayed the Cortes into measures which could not fail to drive the bigots into an open and desperate resistance. One of the first steps against the religious orders was the suppression of those properly called *Monks*,—such as lived under the Ascetic institutions which preceded the establishment of the mendicant orders in the thirteenth century. As their houses were wealthy, this measure might be suspected to proceed rather from a wish to increase the resources of the government, than from ill will to the establishments themselves, which, besides, had long ceased to be objects of veneration for the mass of the people. But when, in the pure desire of removing the most odious nuisance to which the religion of the country has given birth, the Cortes decreed the abolition of the privileges hitherto enjoyed by the heads of the mendicant orders;—when they limited the number of convents, and subjected the individuals resident in each to a local superior, under the jurisdiction of the diocesan;—when impediments were thrown in the way of taking religious vows, and the admission into the secular clergy, of such as were willing to throw off the cowl, was encouraged;—when even the helpless victims of superstition, the nuns, were protected by the civil magistrate, in case they evinced a desire to break the perpetual imprisonment of the cloister;—the alarm of the bigots was turned into downright frenzy, and even the court of Rome, conscious as it is of its weakness, thought it necessary to resent the insult.

A step, much more questionable both as to its policy and justice, was taken by the Cortes against the church interest, in the abolition of one half of the tithes. Had they appropriated this portion of the church property to the use of the State, the spoliation might have been excused upon the plea of necessity. But the Cortes well knew that the farmers, once freed from the religious feeling which enforces the payment of tithes, would find means to defraud the civil authorities of nearly all the sequestrated portion. The measure was, therefore, simply directed to the acquisition of friends to the new order of things.

We mention these detached specimens of the policy of the Cortes, not so much for the sake of their intrinsic importance, as in order to show the temper of the Liberal party, and contrast it with that of their opponents. And here we cannot help lamenting that want of space compels us to omit the details

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contained in the Reports of the Ministers, presented to the Spanish legislature in 1821 and 1822, as to the nature and extent of the resistance offered to the present system by one part of the nation. Cautious as they are in their language, and desirous to make light of the influence and resources of their adversaries, one great and important fact is clearly established from their evidence—a fact which has always forced itself upon our conviction, and which, from the knowledge we have of the country, appears to us in the shape of an almost insuperable obstacle to a speedy triumph of freedom in Spain—namely, that the present is a purely religious contest, in which one party engages with all the sincerity and straight-forwardness of zeal, while the other has to defend itself under the disadvantages of unavowed principles, and disguised views.

The Minister of *Grace* and *Justice* begins his Report of the 1st March 1822, by declaring that "the evils arising from the existing circumstances of the clergy are of the greatest magnitude." He then proceeds to state the questions that had been agitated between the two courts of Rome and Madrid, giving a long detail of the theological and canonical arguments with which the Pope's objections had been met. Of these points some were yielded to the Spaniards, some absolutely insisted upon. But the most resolute opposition had been made against a decree of the Cortes, prohibiting the remittance of Spanish funds for bulls and dispensations. And here we beg our readers to observe the circumstances of the whole transaction, as highly illustrative of the moral and intellectual relations in which the mass of the Spaniards stand, with the small party who have seized the reins of Government. When the Spanish Minister at Rome communicated this decree to the Papal authorities, he found that two thousand five hundred and forty-one bulls had been stopped for want of payment. Alarmed at the consequences of this spiritual embargo, the Spanish government paid the whole amount of the fees. But the sum had scarcely been laid down when the mail brought *fifteen hundred* petitions for bulls of the same private nature. Baffled by the irresistible power of religious prejudice, the Spanish Ministers were under the necessity of engaging for the payment of all bulls relating to Spain, until they should be able to compound with his Holiness for an annual sum. The account of this transaction concludes with the following observation of the Minister: "We shall thus be able to stop the contraband in bulls which has been set on foot already, and which is likely to increase the contributions to Rome to a much greater extent than before, as the parties concerned, finding the regular channels obstructed by government, have had recourse to others which, from their private and confidential nature, will require greater sacrifices on the part of the petitioners." We cannot dismiss this topic without observing, that one of the most certain and abundant sources of revenue arises, in Spain, from the sale of an annual bull, called *the Bull of the Crusade*, which the government (even the *liberal* government) buy of the Pope, and retail to the people. The *Report* of the Minister of Finance for the same year observes, that by the Cortes having placed the produce of this pious sale in the hands of the provincial treasurers, it had diminished from 1,500,000 of *reals* a month, to about 538,360 of the same money. The re-establishment of the *Commissary of the Crusades*, a dignified ecclesiastic, into his former authority, had, however, increased the sale to 1,073,674 reals a month.

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Whatever might be the caution and timidity of the middle classes of Spain, especially those that are possessed of some wealth, or exercise any lucrative branch of industry, it was impossible that the more violent and daring of the sincere Catholics should remain perfectly inactive under a state of things so discordant with the truly national sentiments and habits. The rabble of the large towns, which is numerous, and quite worthy of that name, had, since the revolution of 1820, been gained over to the constitutionalists; but the peasantry, who, to this day, have shown a general dislike of the new system, would afford a considerable number of active and determined partizans to any who should be ready and able to marshal them under the standard of the *Faith*,—a word by which the Spaniards denote the Catholic religion, such as it was established in their country. Few months, indeed, had elapsed, when conspiracies were detected in various parts of the country; and Guerilla parties, in support of *Religion* and *the King*, were found ranging over the provinces. The seeds of a civil war had thus been brought into activity, and in the opinion of all who are well acquainted with the dilatoriness and obstinacy of the Spaniards, the character and circumstances of the contending parties were, alone, enough to threaten the destruction of every source of power, wealth, and happiness, in that devoted kingdom.

Hostility of France to the New Government.

It was not long, however, before a determination was observed, on the part of France, to encourage and support the Spaniards, who were actually in arms, or ready to take them up, against the new system of government. Emigrants were protected on the French side of the frontiers, and enabled to organize themselves into military divisions. The yellow-fever, which attacked Catalonia, in the summer of 1822, afforded a pretext for establishing a *Cordon Sanitaire*, which might act as an army of observation. French money was employed in raising fresh disturbances in the kingdom; and, it is more than probable, French influence fomented the conspiracy of the Guards, which, on the 7th July of the same year, would have placed the King out of the hands of the Cortes if he had had either the will or the courage to join the troops, who awaited his presence at a short distance from the palace.

A congress of the powers which compose what is known by the name of the *Holy Alliance*, was, at this time, about to be assembled at Verona. From the character of the governments of Austria, Prussia, and Russia, and their habitual fears of the spirit of political reform, which for the last thirty years has shaken the foundations of all absolute monarchies, it could hardly be imagined that Spain should pass unnoticed at this meeting. Nor was it long before the disclosure of their views and principles, joined to the open avowal of hostile intentions against Spain, on the part of France, evinced a settled and systematic plan for restoring absolute mo-

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narchy in the former kingdom, and opposing, throughout Europe, every curtailment of monarchical power, however exorbitant and oppressive, and every attempt to establish the liberties of the subject, upon permanent and definite grounds. In vain did England remonstrate against the impolicy and injustice of interfering with the domestic concerns of an independent nation. Notes, conceived in a spirit, and couched in a style which could only irritate the feelings of the constitutionalists, and strengthen their hands by wounding the pride of the nation, were addressed by the three Sovereigns of Austria, Prussia, and Russia, to their Ministers at Madrid, demanding a change in the constitution, as the condition of the permanence of these accredited agents at that court. Lest Europe should be left in doubt as to the nature of the changes thus peremptorily required, the French King, on the 28th of January 1823, announced to the Chambers, that he had one hundred thousand troops ready to march into Spain, unless Ferdinand VII. were allowed *to give to his people institutions which they cannot hold but from him.*

A principle so monstrous, backed by a threat so unbecoming and dissonant, in the mouth of one who has had so long to shrink from military force, could not but urge the Spanish governors into a determined resistance to any proposals of accommodation which should imply the least yielding on their side; and the invasion of Spain by a French army, with the avowed purpose of restoring despotism, the monks, and the Inquisition, took place on the 17th of April 1823, about the time when, fifteen years before, another French army violated that territory, under pretence of giving it a Constitutional Code, and wiping off the disgrace which those barbarous institutions cast upon the national character. * (S. S. S.)

Extent, Boundaries, and Divisions.

STAFFORDSHIRE, an inland English county of an oblong form. Its greatest length from north-east to south-west is about sixty, and its greatest breadth about thirty-eight miles. It contains 1,148 statute square miles, or 734,720 acres. It is bounded on the north by Cheshire, west by Shropshire, south by Worcestershire and Warwickshire, and east by Derbyshire. The great divisions are five hundreds; but, as each of these is subdivided into the north and south portions, there are effectively ten hundreds. These contain 181 parishes, 23 market towns, and one city. The whole of the county, with the exception of two parishes, is within the diocese of Lichfield and Coventry, and comprehended within the archdeacoury of Stafford.

Population.

According to the census of 1821, the increase of the population in the preceding ten years had been at the rate of sixteen *per cent.* At that period, the inhabited houses were 63,319, and the families occupying them 68,780; of these families, 18,285 were chiefly employed in agriculture, 42,435 in trade, manufactures, and handicraft, and 8060 comprised in neither of those classes. The whole number of persons was 341,040; of whom 171,668 were males, and 169,372 females.

Face of the Country.

The middle and southern portions are generally level, but interspersed with gentle eminences. The northern division is of an opposite character, the surface being for the most part bleak and hilly. The general elevation of this district above the southern part of the county is about two or three hundred feet; but some points rise to the height of from 1200 to 1500; of those the most elevated are Bunster and the Weever Hills. In the valleys on the banks of the rivers are some tracts of country equal to the most beautiful parts of the island; of these, the district betwixt Lichfield and Stone, and the picturesque banks of the Dove, especially at Ilam, are very remarkable.

Soil and Climate.

The soil is various, but the strong clays are the most predominant; next in extent is the sandy soil, chiefly to the south of the Trent. There is no chalk, and only a small district is calcareous. The meadows, especially on the banks of the Trent, are most rich and luxuriant; and, though on spots there is much inert peat, yet, when it is drained properly, it becomes valuable pasture and meadow land. The climate is generally raw and moist; the rain that falls on an average of several years is about 36 inehes. The quantity of snow, in the winter on the moorlands, is very great, which may contribute to the general coldness of the district.

Rivers and Navigable Canals.

The Trent, the third river in England, is the principal stream of the county. It rises at Newpool on the confines of Cheshire, and enters Derbyshire below Burton, after having formed a junction with the Dove; through the whole of its course in this county it is a clear and rather rapid stream.

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* By a proclamation of the Spanish Regency, an authority established by the French, every public act since the Revolution of 1820 has been declared null and void, and the country is to be reinstated into the same condition as it had been before that change. The moderation with which, during the interval of writing and publishing this article, the Prince D'Angouleme has behaved in Spain, though it can never justify the armed interference of his government, might seem to invalidate our charge, as to the intended restoration of the Inquisition. What the real feelings of his Royal Highness's government may be upon this point, the author of the article has not the means to ascertain; but he knows too well the spirit of the party, into whose hands it appears that the French wish to put the fate of the Spaniards, not to fear that the execrable tribunal, to which Spain owes her degradation and sufferings, will re-appear in that unfortunate country. Should his suspicions prove true, he has no hesitation to assert, that all the blame and disgrace of such a restoration belongs to those who, when they were determined to interfere with the private concerns of the Spaniards, did not care to extenuate the infringement of national rights, by any stipulations in favour of the general interests of the invaded country.

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The Dove is celebrated for the picturesque scenery through which it flows. In its course it receives the Manifold and the Hamps, two streams which are lost in subterraneous channels, but again emerge at the distance of some miles, and rejoin it. The smaller rivers are the Tame, the Blythe, the Sour, and the Penk, all of which empty themselves into the Trent. No part of Great Britain is so intersected with navigable canals as Staffordshire, and in no country has their beneficial effects been so extensively experienced. The Grand Trunk was planned and executed by Mr Brindley, the most eminent engineer that ever exerted talent in this peculiar branch of inland navigation. This canal is about 91 miles in length; the fall of water to the north is 326 feet, and to the south 316 feet. It is 29 feet wide at the top, and about four feet deep. It unites by navigation the internal trade of the great marts of London, Liverpool, Hull, and Bristol. The branches that extend from it in every direction are very numerous, and serve to connect the great shipping ports with all those districts, in the centre of the kingdom, which produce those heavy commodities whose weight would make them almost worthless without the means of cheap conveyance to distant markets.

Minerals.

The chief mineral productions of the county are iron and coal, and these are so copious that they appear to be almost inexhaustible. Upwards of 50,000 acres have been already ascertained to have beneath them beds of coal; and, notwithstanding the length of time, and the extent to which they have been worked, it is calculated that not one-tenth of their contents have been yet consumed. The strata of this mineral, in the mines already worked, vary in thickness from 24 to 36 feet. Every portion of the coal district abounds in iron ore; and the strata of that mineral are generally found beneath a stratum of coal. Copper and lead are also raised, but not to an extent nearly approaching that of iron. Limestone, freestone, alabaster, marble, ochre, gypsum, and clays of various descriptions, applicable to the purposes of the potteries, are most abundantly extracted from the bowels of the earth. Though salt springs are both copious and richly impregnated with that mineral, no rock salt has been yet discovered; but it is supposed there are some abundant repositories of it beneath the surface.

Manufactures.

The relative proportion of the employment of the several families show the great preponderance of manufacturing labour in this county. The whole of the southern part is occupied in the different workings of metals. Wolverhampton is the chief seat of the manufacture of locks, keys, hinges, bolts, and the heavier kinds of iron ware. Walsal furnishes buckles, bitts, stirrups, spurs, and all the kinds of hardware used by saddlers. Wednesbury supplies guns, iron axle-trees, saws, trowels, hammers, edge tools, and cast-iron works of every kind. Almost all the villages in the vicinity of these towns contribute in a greater or less degree to supply part of the work for which the town nearest to them is the great mart.

The northern part of Staffordshire is celebrated for the excellence of its earthenware, with which it supplies the consumption of the greater portion of the civilized world. The great extension of this manufacture has been owing to the scientific skill and persevering energy of one distinguished individual, the late Mr Wedgewood; whose combinations of the different earths, and study of the arts of design, has given a value to that which before was almost worthless, and increased to a most wonderful extent the wealth of his neighbourhood, and the number and comfort of its inhabitants. By means of the canals, the pipe-clay from Dorsetshire and Devonshire, and the flints from Kent, are brought to the spots where the clays and coal abound; and the finished goods, by the same means, are conveyed to the great shipping ports, from whence they are distributed to all parts of the globe. Salt is made from natural springs at Shirleyweck, and, of late, at Lord Talbot's works at Ingestrie, to such an extent as to supply all those parts of the middle of the kingdom which are not in more close contact with the refineries of Northwich or Droitwich. There are some respectable establishments at Cheadle for making brass and copper goods. Shoes are manufactured on an extensive scale at Stafford and at Newcastle. At Tamworth are great works for printing calicos. Burton has manufactures of ale, of great celebrity, of hats, and of several kinds of cotton goods. At Leek there are large and flourishing establishments for ribbons, handkerchiefs, ferrets, galloons, and other kinds of silk goods.

Agriculture.

The cultivated lands of this county are nearly all inclosed within good hedges, chiefly of the white thorn, in fields of from twenty to thirty acres. The general rotation of crops in the clayey soils is, 1st, Fallow; 2d, Wheat; 3d, Oats, after which it is laid down with clover, trefoil, and rye-grass, for two or more years. On breaking up an old sward, the usual course is, 1st, Oats; 2d, Fallow; 3d, Wheat; 4th, Oats, and then the grasses. On the more friable soils the rotation is, 1st, Fallow; 2d, Wheat; 3d, Beans, or pease; 4th, Oats, and then the grasses. On the light soil, the Norfolk system of turnips, barley, clover, and then wheat, is most commonly followed.

The black cattle are generally of the long-horned breed, and have, of late years, been much improved by the spirited exertions of some distinguished individuals. The sheep are of different races; the new Leicesters are said to be the most predominant. About Cannoch and Sutton Colfield they have a breed much resembling the South Downs. On the moorland there is a breed with white faces, without horns, and long combing wool. The county is well stocked with timber, especially on the estates of some of the great proprietors. The lands in an unimproved state are still estimated to amount to nearly one-tenth part of the whole county.

Antiquities.

The Roman antiquities are the Watling Street and the Ichnield roads, which pass through it, and the remains of ancient stations or encampments. The Saxons have left few remains here that merit particular attention.

Titles, and Representation.

This county gives titles to the following peerages: Marquis of Stafford, Earls of Ferrers, Talbot, and Harrowby. The county returns two members to the House of Commons, and two each are sent from Lichfield, Stafford, Newcastle, and Tamworth.

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The most remarkable noblemen and gentlemen's seats are the following: Trentham, Marquis of Stafford; Beaudesert, Marquis of Anglesea; Ingestrie, Earl Talbot; Sandon, Earl of Harrowby; Sandwell, Earl of Dartmouth; Enville, Earl of Stamford; Shugborough, Lord Anson; Wrothesley, Sir J. Wrothesley; Wolsely Hall, Sir Charles Wolsely; Tixtall, Sir T. H. Clifford; Etruria, Josiah Wedgewood, Esq.; Weston, Earl Brodford.

Population of Principal Places.

The population of the principal places are as follows: Wolverhampton, 18,380; Sedgley, 17,195; Bilston, 12,003; Walsal, 11,914; Tipton, 11,546; Kingswinford, 11,022; Burslem, 9699; West Bromwich, 9505; Lane End and Longton, 7100; Newcastle-under-Line, 7031; Wednesbury, 6471; Lichfield, 6075; Rowley Regis, 6062; Stafford, 5736; Henley, 5622; Darlaston, 5585; Uttoxeter, 4658; Burton-upon-Trent, 4114.

See Plott's *History of Staffordshire*; Pitt's *Agricultural Survey of Staffordshire*; Aiken's *History of Manchester*; Shaw's *History and Antiquities of Staffordshire*; Jackson's *History of Lichfield*; *Beauties of England and Wales*. (W. W.)

STEAM-ENGINE, Perkins's. In addition to the detailed theory of Steam, and of the Steam-Engine,* such as it has already been furnished by the science of a Robison, and the ingenuity of a Watt, some further theoretical investigations and computations are still required from time to time, in order to keep pace with that restless spirit of incessant speculation and practical improvement, to which Great Britain is indebted for so much of its prosperity; and none of the inventions which have of late been introduced are so striking, so promising, or at first sight so paradoxical, as those which have resulted from the skill and enterprise of Mr Perkins. In order that we may be prepared to appreciate the merit of these inventions, and to discriminate between the effects which are the results of new philosophical principles, and those which are only obtained from a high perfection of mechanical execution, and a just confidence in the admirable art with which the materials are selected and tempered; it will be necessary to recur to the theories of heat and of steam which have been already founded on acknowledged facts, and to inquire how far they will carry us in explaining all that has hitherto been made public respecting the machinery which has excited so much attention, before we allow ourselves to reject the principles [of *Atmology*] at present admitted, as either erroneous or insufficient.

Respecting the density, or specific gravity, of steam at different temperatures, there appear to have been three different opinions; that of Mr Wolf, who fancied that it was nearly equal in all cases, and that the difference of elasticity depended only on the immediate effect of heat; that of Mr Southern, who inferred from his experiments that the density was simply proportional to the elasticity, without any regard to the effect of temperature; and thirdly, the earlier and more probable theory of Mr Dalton, which is intermediate between them, and which attributes the same effect to heat in the expansion of pure steam that it possesses with respect to all other gases, amounting for each degree of Fahrenheit to about $\frac{1}{500}$ of their bulk at 52°, or to $\frac{1}{650}$ at 212°, provided that no additional quantity of moisture be present to furnish fresh steam by its evaporation. The elasticity might be computed from Dr Young's formula $e=.1781\,(1+.006f)^7$, in which f is reckoned from the freezing point, and which agrees sufficiently well with the latest experiments of Southern and Ure, as well as with the earlier ones of Watt, Schmidt, Biker, Bétancourt, Robison, Dalton, and others; and we might transform it into the more convenient expression $E=(1+.0029f)^7$, for the number of atmospheres expressing the elasticity, reckoning the f from 212°. But since Mr Southern's experiments, as described in Robison's *System of Philosophy*, were carried to higher temperatures than any of those which had been before made public, it will be safer to adopt an exponent approaching more nearly to that which he has employed, and to make $E=(1+.004f)^5$. Notwithstanding, however, the apparent accuracy of these experiments, it seems impossible to rely on them with perfect confidence; they give, for example, the absolute specific gravity of steam at 212°, $\frac{1}{1600}$; while Sir Humphry Davy's very accurate observation of the perfect identity of the space occupied by oxygen and hydrogen before and after deflagration, makes it only $\frac{1}{2600}$, which agrees very nearly with the experiments communicated by Mr Davies Gilbert to Dr Young (*Nat. Phil.* II. p. 397), as well as with the much older determination of Desaguliers.

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We obtain, upon these principles, the following Table of the elasticities and densities:

Atmospheres.	Temperature.	Difference.	Compar. Density.	Specific Gravity.
1	212°		1.000	1:2600
2	249	37°	1.896	1:1371
3	273	24	2.742	1:912
4	292	19	3.565	1:729
5	307	15	4.366	1:596
6	320	13	5.150	1:505
7	331	11	5.917	1:439
8	341	10	6.678	1:390
9	350	9	7.432	1:350
10	358	8	8.170	1:318
15	388	—	11.820	1:220
20	417	—	15.232	1:171
30	456	39	21.834	1:120
40	485	29	28.210	1:92
50	509	24	34.388	1:76
60	529	20	40.404	1:64
70	547	18	46.265	1:56
80	562	15	52.083	1:50
90	577	15	57.766	1:45
100	590	13	63.371	1:41
1000	957	—	465.33	1:5.6
2000	1105	148	845.31	1:3.1
3000	1202	97	1193.00	1:2.1

* There are, in the *Encyclopædia Britannica*, very full articles under these heads, from the pen of the late Professor John Robison.

There is another of Mr Southern's opinions, which it appears to be almost as difficult to reconcile with other considerations as his conclusions respecting the absolute and relative densities of steam: he imagines that the heat consumed in the formation of steam is almost all employed in the simple conversion of the liquid into a gas, without any great deduction for that which is required for its expansion; while, on the other hand, if we adopted Dr Young's computation, deduced from the effect of expansion and compression on the velocity of sound, we should be obliged to infer, that almost the whole of the heat is required for the expansion only, and very little, if any, would be left to supply what Mr Southern calls the *constitutional* heat of the steam, in contradistinction to the heat of *expansion*. Dr Young's book is so little known, though it has been sixteen years before the public, that it will not be superfluous to extract from it the computation in question, which bears immediately upon the utility of all engines with high pressure.

"We may deduce from" Mr Dalton's "experiment," says Dr Young (Vol. II. p. 409), "an acceleration of about $\frac{1}{7}$ to be added to the calculation of the velocity of sound; and, since the results of [direct] experiments on sound require an acceleration of $\frac{1}{5}$, or only $\frac{1}{3}$ more, which has been ascertained with great accuracy, it may be fair to allow the supposition of Laplace and Biot, that the whole acceleration of sound is owing to this cause. We may, therefore, make the exponent of the density $\frac{1}{8}$ for expressing the change of capacity, and the heat produced 1450 $(x^{1}—1)$; which, when the density is doubled or halved, becomes 131.2°; [and] a compression of $\frac{1}{180}$ will produce a heat of 1°.

"Now, it appears from experiments on the sounds of different gases, and from the sound of a pipe in air of densities the most various, that the correction of the velocity of sound is nearly the same in all; hence it may be inferred, that the heat produced by condensation follows nearly the same law with respect to all gases. This principle may, therefore, probably be extended to steam. Supposing the conversion of water into steam to absorb as much heat as would raise its temperature 940°, we may call its capacity at 212°, 1.60, and may calculate a table for other temperatures, assuming, with Mr Dalton, that its simple expansion by heat is equal to that of air. Mr Watt has shown, by direct experiment, that steam has a greater capacity, as its temperature is lower.

"Hence, if a steam-engine work with double atmospheres, the heat being about 247°, it will require 1.87 times as much water, of which the capacity [as steam] is 1.48; and its excess above that of water $\frac{4}{5}$ as much as at 212°; it will therefore absorb about 752°, and the heat required for raising water from 100° will be as 1.87 (147+752) to 112+940, or nearly as 8 to 5, while the effect is doubled.

"Robison says, that four ounces of water, at 100°, will condense in a second nearly 200 cubic feet of steam, reducing its expansive force to $\frac{1}{5}$. If this is correct, it sets at defiance all theories of capacity. The only distant analogy that can be found for it, is the facility with which rarified air is found to carry off heat, which would induce us to suppose, that the capacity of a given bulk of air is much less affected by its density than this calculation appears to demonstrate;" and this apology, if we allowed it any weight, would carry us still farther from Mr Southern's opinion."

The two steps by which Dr Young's argument proceeds are, first, the effect of compression on air, as deduced from Laplace's ingenious and fortunate suggestion respecting the velocity of sound; and, secondly, the identity of this effect, as observed by himself and others, in air of different densities, and in gases of different kinds; whence he infers, that the same law may *probably* be extended to steam; that is, as far as we can depend on such analogies as have been employed in the doctrine of the capacities of bodies for heat, which, however, appear to be by no means unobjectionable. A remarkable consequence of this mode of computation would be, that water might be converted into steam of its own density almost without any expense of heat whatever for what Mr Southern calls its constitutional heat; for if we make $x=\frac{1}{2600}$ in the formula 1450 $(x^{\frac{1}{8}}—1)$, we have 907° for the change of temperature attending such a compression or expansion; and the result would be still greater, if we supposed the heat evolved to be expressed by $n \log x$, taking n above 400°, for the multiplier of the common logarithm of the density. Probably, indeed, both these modes of computation give a change of temperature greater than the truth for the effect of any very considerable compression or expansion of steam; but the lowest estimate that we can form of this effect will still make it probable that steam is always cooled by its expansion below the temperature which would allow it to subsist in its rarified state as pure steam; or, in other words, that a deposition of moisture is always immediately produced by its expansion, and that steam is rendered drier by compression, supposing no heat to be absorbed or emitted in either case. The very low temperature at which a thermometer stands, in the steam that issues out of a boiler under a very high pressure, is a further proof of the great increase of its capacity, or of the great absorption of heat occasioned by the expansion.

Mr Perkins's invention, as described in the *Edinburgh Philosophical Journal* for July 1823, appears to consist in substituting for the boiler a strong vessel of gun metal, which he very properly calls a *generator*, intended to subject the water to a heat of between 400° and 500°, and allowing it to escape only through a valve loaded with a weight equivalent to 35 atmospheres, while it is furnished with a safety valve loaded to 37, and with a gage indicating, by means of a portion of compressed air, the actual pressure of the steam produced by it; and even the water that returns to the generator is subjected to a pressure of five or six atmospheres, which keeps it at a temperature of more than 300°. The generator contains eight gallons of water, or 2352 cylindrical inches, while the piston is two inches in diameter, and the cylinder 18 inches long, containing 72 cylindrical inches, or $\frac{1}{33}$ as much as the generator: affording a stroke of 12 inches, with a pressure

initially of about 430 pounds on each square inch, that is, about 1300 pounds in the whole, or probably somewhat less, since the valve of the generator cannot be supposed to remain open long enough for the pressure on each side of it to become equal. The danger of explosion, which has hitherto prevented the general employment of engines with very high pressures, is here avoided by the great strength and the moderate dimensions of the apparatus; and besides the safety valves, a thin ball of copper, or a safety bulb, is provided, which will only sustain the pressure of 1000 pounds on the square inch, while every other part of the vessels is calculated to sustain 4000.

Mr Perkins's mode of applying heat to the water appears in reality to be extremely advantageous, not so much from any evidence that has been produced respecting the performance of the engine, as from the fact asserted by the writer in the *Journal*, that "as much low pressure steam, of four pounds on the square inch, may be generated by *one* bushel of coals," employed upon three tubes of gun metal, communicating, by means of a loaded valve, with the boiler of a common engine, as by *nine* bushels applied in the ordinary manner. It has been conjectured that the heat is more easily communicated by the generator to the water, on account of the more intimate contact which subsists between them, and the absence of any nascent bubbles of steam in the neighbourhood of the common surface: but it appears to be more probable, that by far the most material part of the advantage depends upon the more perfect combustion of the coal at a high temperature near the external surface of the thick boiler: for it has been sufficiently proved by Sir Humphry Davy and others, that an intense combustion evolves a much greater quantity of heat from the same materials than a more languid oxygenization.

However this may be, there is nothing paradoxical, and nothing marvellous in the operation of the engine itself, nor in the rapid production of a quart of steam from eight gallons of water "almost red hot." The writer in the *Journal* has fancied that the water, as it "flashes out," *may* rob the neighbouring particles of their heat, so as even to leave them below the freezing temperature, while it is itself much above the boiling: but this supposition is in direct opposition to every thing that we know of the properties of heat. If we reason at all in natural philosophy, we must reason from analogy: such a phenomenon as this would be incredible, even if it were asserted upon the direct and clear testimony of the senses; but to assume it as a probability, without pretending that it has been observed, appears to be setting completely at defiance the obvious dictates of common sense. There is *no other instance whatever* in which a body, contiguous to another, and exceeding it in thermometrical temperature, does not communicate heat to it rather than receive heat from it: nor, on the other hand, is there any one fact besides, that could be imagined to favour the hypothesis of a sudden and general communication of heat between the distant parts of a material substance, like that which appears to take place with regard to the electrical fluid.

The quantity of water, thrown out at each stroke, appears, from the table of densities inserted in this article, to be $\frac{1}{110}$ of the quantity that would fill the cylinder, that is $\frac{1}{3030}$ of the content of the generator, and its conversion into steam at any temperature would not require, at the utmost, more than 940° of heat, that is, a quarter of a degree for the whole of the water in the vessel, and possibly not above one fifth of a degree: and it is obvious that the parts nearest the surface might easily furnish this with sufficient rapidity, and yet without approaching very near to the "freezing temperature."

But whatever mistakes may have been made respecting the principles of Mr Perkins's engine, there can be no reason to doubt of its possessing some considerable advantages in practice, which he will probably soon be enabled to establish, by the accurate test of its performance in pumping up water, as compared with that of the engines at present in common use, which are said to be capable of raising a weight equal to that of the coals consumed to the height of above half a million of feet: so that, in order to make good the expectations that have been held out to the public, he will have to raise an equal weight to about five million feet; and when this has been performed, he will have triumphantly redeemed the pledge that has been given on his behalf.

(A. L.)

STEAM-NAVIGATION.

History of Steam-Navigation.

The idea of propelling vessels by the action of wheels or paddles, instead of oars, seems to have occurred at a remote period. The mode of carrying the project into execution is clearly, though concisely, described in a very curious and learned treatise, *De Re Militari*, by Valturius of Rimini. This remarkable work is justly deemed one of the finest and earliest specimens of typography and wood-engraving. It was first printed by John of Verona in 1472, and from the same press an Italian translation of it by Paul Ramusio issued in 1483. It was afterwards reprinted at Paris in 1532, in the original Latin, by the celebrated Printer, Christian Wechelius.

Of the numerous machines described and delineated in that rare volume, several have been frequently reproduced as new inventions during the course of the last century. Such waste of ingenuity is really a serious evil, arising from inattention to the history of the mechanical arts, and the want of a public repository to exhibit their successive improvements. Mr Dibdin has given, in his *Bibliotheca Spenceriana*, fac-similes of several warlike engines from Valturius; but we have copied the figure of a

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flat-bottomed boat for crossing rivers by the circumvolution of paddles or vanes. (See Plate CXVI.) These vanes consisted of pitched sail-cloth; and it will be seen, that the impulsion was communicated by means of cranks. The action of each axle is said to have been equivalent to that of twelve oars. (Valturius, *De Re Militari*, p. 314.) We must not, however, suppose that the power thus applied was really augmented by such machinery. It has been ascertained that human force is advantageously exerted in the act of rowing; but this operation requires skill, and not more than one person can work conveniently at the same oar. Where paddles are substituted, mere strength is sufficient; and a number of men may combine their labour in turning a crank. Animal power will, indeed, effect the same purpose. Accordingly, some of the broad ferry-boats in North America are fitted with paddles driven by gin-horses.

It is clear, therefore, that, three or four centuries ago, boats, propelled by the action of paddle-wheels, were used on some of the large rivers in Italy, and, most probably, in other parts of the Continent, for the transporting of troops. Valturius even speaks of pontoons, composed of three parts, like drums, which could be conjoined at any time, and again separated, to facilitate their carriage over land. The method of changing a reciprocating into a rotatory motion, by the help of a crank, though not applied to the steam-engine till 50 or 60 years after its invention, had been understood and practised at the very dawn of the mechanical arts.

The atmospherical steam-engine, which had been invented by Newcomen and improved by Beighton, began to be pretty generally adopted in the coal-works about the year 1720; and it does not seem to have required any great stretch of imagination to direct such an efficient power to other purposes besides the raising of water.

Mr J. Hulls.

The first attempt, however, on record to apply steam to navigation was made by a person of the name of Jonathan Hulls, who, on the 21st of December 1736, obtained a Patent, to endure for 14 years, for what may, without any impropriety, be called a *Steam-Boat*. The Letters Patent, and a description of this boat, illustrated with a plate, are contained in a very rare Tract, published by Hulls in 1737, under the following title: *A Description and Draught of a new invented Machine for carrying Vessels or Ships out of or into any Harbour, Port, or River, against Wind and Tide, or in a Calm.* As the origin of the invention has been much disputed, we shall subjoin some extracts from this pamphlet, which lay totally forgotten till within these few years, and is even yet, on account of its great rarity, but very little known.*

He introduces his description by a concise view of the principles of experimental philosophy; in which he observes (p. 39), " If a person were to descend to the bottom of a well full of water, his body would be pressed the same as if he descended the same depth into the sea; for there is the same pressure against a pool-head as there is against the sea-bank at the same depth, as hath before been demonstrated.

" Thus I have endeavoured to explain the nature of the pressure of the air on other bodies, by comparing it with other fluids that are visible to our eye, as mercury, water, &c. and, since the pressure is so very great, it is the more fit to be applied to a purpose wherein all sorts of manual operations are insufficient. For this present undertaking cannot be supposed to be done by strength of men or horses, or any machine driven by either.

" The atmosphere being of a great weight, and striving to get in where there is a vacuum, I shall endeavour to show how this vacuum is made, and in what manner this force is applied to drive the machine.

" In some convenient part of the Tow-Boat there is placed a vessel about two-thirds full of water, with the top close shut; this vessel being kept boiling, rarifies into a steam. This steam being conveyed through a large pipe into a cylindrical vessel, and there condensed, makes a vacuum, which causes the weight of the atmosphere to press on this vessel, and so presses down a piston that is fitted into this cylindrical vessel, in the same manner as in Mr Newcomen's engine, with which he raises water by fire. (See Plate CXVI.)

—" It hath been already demonstrated, that a vessel of thirty inches diameter, which is but two feet and an half, when the air is driven out, the atmosphere will press on it to the weight of four tons, sixteen hundred weight, and upwards; when proper instruments for this work are applied to it, it must drive a vessel with a great force."

" *Note.*—The bigness of the machines may be proportioned to the work that is to be performed by them; but, if such a force as is applied in this first essay be not sufficient for any purpose that may be required, there is room to make such addition as will move an immense weight with tolerable swiftness.

" It is my opinion it will not be found practicable to place the machine here recommended in the vessel itself, that is to be taken in or out of the port, &c. but rather in a separate vessel, for these reasons:—

" 1*st*, This machine may be thought cumbersome, and to take up too much room in a vessel laden with goods, provisions, &c.

" 2*d*, If this machine is put in a separate vessel, this vessel may lie at any port, &c. to be ready on all occasions.

" 3*d*, A vessel of a small burthen will be sufficient to carry the machine to take out a large one.

" 4*th*, A vessel will serve for this purpose for many years, after she is thrown off, and not safe to be taken abroad."

The passages above quoted are followed by the

* It consists of forty-eight pages, in duodecimo; was " printed for the author, and sold, price sixpence, at the Pamphlet Shops in London and Westminster."

Explanation of the Machine. The Figure to which this *Explanation* refers is copied, from that given by Hulls, in Plate CXVI.

"*A* represents the chimney coming from the furnace.

"*B*, The tow-boat.

"*CC*, Two pieces of timber, framed together, to carry the machine.

"*Da*, *D*, and *Db*, are three wheels on one axis, to receive the ropes *F*,*Fa*, and *Fb*.

"*Note.*—*F* is the same rope that goes into the cylinder.

"*Ha* and *Hb* are two wheels on the same axis with the fans *IIIII*, and move alternately in such a manner, that when the wheels *Da*, *D*, and *Db*, move backward or forward, they keep the fans *IIIII* in a direct motion.

"*Fb* is a rope going from *Hb* to *Db*, that when the wheels *Da*, *D*, and *Db*, move forward, moves the wheel *Hb* forwards, which brings the fans forward with it.

"*Fa* is a rope going from the wheel *Ha* to the wheel *Da*, that when the wheels *Da*, *D*, and *Db*, move forward, the wheel *Ha* draws the rope *F*, and raises the weight *G*, at the same time as the wheel *Hb* brings the fans forward.

"When the weight *G* is so raised, while the wheels *Da*, *D*, and *Db*, are moving backward, the rope *Fa* gives way, and the power of the weight *G* brings the wheel *Ha* forward, and the fans with it, so that the fans always keep going forward, notwithstanding the wheels *Da*, *D*, and *Db*, move backwards and forwards, as the piston moves up and down in the cylinder.

"*LL* are teeth for a catch to drop in from the axis, and are so contrived, that they catch in an alternate manner, to cause the fans to move always forward, for the wheel *Ha*, by the power of the weight *G*, is performing his office, while the other wheel *Hb* goes back in order to fetch another stroke.

"*Note.*—The weight *G* must contain but half the weight of the pillar of air pressing on the piston, because the weight *G* is raised at the same time as the wheel *Hb* performs its office, so that it is, in effect, two machines acting alternately by the weight of one pillar of air of such a diameter as the diameter of the cylinder is.

"If it should be said that this is not a new invention, because I make use of the same power to drive my machine that others have made use of to drive theirs for other purposes; I answer, The application of this power is no more than the application of any common and known instrument used in mechanism for new invented purposes." P. 43.

This Explanation is followed with the annexed "*Answers to some Queries that have been made concerning the possibility and usefulness of this undertaking.*"

"QUERY I.

"Is it possible to fix instruments of sufficient strength to move so prodigious a weight as may be contained in a very large vessel?

"Answer. All mechanics will allow it is possible to make a machine to move an immense weight, if there is force enough to drive the same; for every member must be made in a proportionable strength to the intended work, and properly braced with laces of iron, &c. so that no part can give way or break, if the braces, &c. necessary for this work had been put in the draught, it would have been so much crowded with lines, that the main instruments could not be so well perceived.

"QUERY II.

"Will not the force of the waves break any instrument to pieces that is placed to move in the water?

"Answer. *First*, It cannot be supposed that this machine will be used in a storm or tempest at sea, when the waves are raging; for, if a merchant lyeth in a harbour, &c. he would not choose to put out to sea in a storm, if it were possible to get out; but rather stay until it is abated.

"*Secondly*. When the wind comes a-head of the tow-boat, the fans will be protected by it from the violence of the waves; and when the wind comes side-ways, the wind will come edge-ways of the fans, and therefore strike them with the less force.

"*Thirdly*. There may be pieces of timber laid to swim on the surface of the water on each side of the fans, and so contrived as they shall not touch them, which will protect them from the force of the waves. Up inland rivers, where the bottom can possibly be reached, the fans may be taken out, and cranks placed at the hindmost axis, to strike a shaft to the bottom of the river, which will drive the vessel forward with the greater force.

"QUERY III.

"It being a continual expence to keep this machine at work, will the expence be answered?

"Answer. The work to be done by this machine will be upon particular occasions, when all other means yet found out are wholly insufficient. How often does a merchant wish that his ship were on the ocean, when, if he were there, the wind would serve tolerably well to carry him on his intended voyage, but does not serve, at the same time, to carry him out of the river, &c. he happens to be in, which a few hours work of this machine would do. Besides, I know engines that are driven by the same power as this is, where materials for the purpose are dearer than in any navigable river in England; therefore, experience demonstrates, that the expence will be but a trifle to the value of the work performed by those sort of machines, which any person that knows the nature of those things may easily calculate." P. 45—48.

Thus, Jonathan Hulls appears to have been the first person who suggested the propulsion of vessels by paddle-wheels *moved by steam.* His mode of converting the rectilineal into a rotatory motion was ingenious, though not so simple as the crank. It is most probable, however, that he possessed not the means, and did not receive at the time sufficient encouragement to carry his scheme into execution.

Marquis De Jouffroy.

A long interval elapsed before a similar project was attempted. About the year 1772 the celebrated Mr Watt had completely remodelled the steam-engine;

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and before 1779 it was, by various improvements, reduced to a compendious form, and adapted to almost every purpose where great power was required. The idea of employing it to propel vessels then naturally suggested itself. One of the first to whom it occurred was the Marquis De Jouffroy, who, in 1781, constructed a steam-boat on the Saone at Lyons; it was 140 feet long, and he made several experiments with it.

Messrs Fitch and Rumsey.

In the year 1785 two keen competitors for the invention of steam-navigation appeared in America; namely, James Rumsey of Virginia, and John Fitch of Philadelphia. The following extracts from a Pamphlet, very little known in this country, published by the latter in 1788, are curious: *

—"I confess the thought of a steam-boat, which first struck me by mere accident, about the middle of April 1785, has hitherto been very unfortunate to me; the perplexities and embarrassments through which it has caused me to wade far exceed any thing that the common course of life ever presented to my view."—"In June and July I formed models, and in August laid them before Congress, as will appear on their files. In September I presented them to the Philosophical Society, as *per* certificates."—

"Philadelphia, Sept. 27, 1785. At a special meeting of the American Philosophical Society, a model, accompanied with a drawing and description of a machine for working a boat against the stream, by means of a steam-engine, was laid before the Society by John Fitch."

"At a meeting of the American Philosophical Society on December 2, 1785, a copy of the drawing and description of a machine for working a boat against the current, which some time ago was laid before the Society by Mr John Fitch, he this evening *presented* to them.

"Extract from the Minutes,

"Samuel Magaw,
"one of the Secretaries."

—"In October I called on the ingenious Mr Henry of Lancaster, to take his opinion on my *drafts*, who informed me that I was not the first person who had thought of applying steam to vessels; that he had conversed with Mr Andrew Ellicot as early as 1775, and that Mr Paine, author of *Common Sense*, had suggested the same thing to him in the winter of 1778."

"In Virginia I waited on his Excellency General Washington, who, in the course of conversation, informed me, that the thought of applying steam was not original; that Mr Rumsey had mentioned steam to him: but nothing that passed in the conversation with General Washington had the least tendency to convey the idea of Mr Rumsey's relying on steam; and General Washington's letter, p. 10 of Mr Rumsey's pamphlet, clears up the matter—for the General himself did not conceive any such thing. Knowing that the thought of applying steam to boats had been suggested by other gentlemen long before; I left his Excellency, with all the elated prospects that an aspiring projector could entertain, not doubting but I should reap the full benefit of the project: for although I found that *some* had *conceived* the thought before, yet I was the first that ever exhibited a plan to the public; and was fully convinced that I could not interfere with Mr Rumsey, otherwise the known candour of General Washington must have pointed out to me such interference. I immediately applied to the Legislature of Virginia for assistance to execute my plan, who signified their wish to encourage my designs, but that the state of their finances prevented it."

"Finding that undoubtedly I was the first person in America that could be termed the inventor of a steam-boat, either agreeably to custom or equity, I thought it prudent to apply to the different states for the exclusive privileges for the emoluments of such invention, which were granted by New Jersey in March 1786, by Delaware, New York, and Pennsylvania, in the winter and spring following, and by Virginia in October 1787.

"I have from the time of my first thought pursued my scheme with unremitted application, without a suspicion of an interruption, until the circulation of Mr Rumsey's invidious pamphlet, the contents of which I now find it necessary next to take under consideration, not doubting but that the design and tendency of that production will be a sufficient apology for the plainness with which I shall treat it."

"Mr Rumsey says, in page 2, that 'in the month of September 1784, he exhibited the model of a boat to his Excellency General Washington, at Bath, in Berkeley county, calculated for stemming the current of *rapid rivers only*, constructed on principles very different from his present one. Satisfied,' says he, 'of the experiment of her making way against a rapid stream, *by the force of the stream*, the General was pleased to give me a most ample certificate of her efficacy.' Here it is to be observed, that no mention was made to General Washington of *steam* at the time of such exhibition: the principles upon which the boat was propelled were entirely unconnected with, and distinct from steam; being simply a model, propelled by *water wheels, cranks, and setting poles*; a mode which was many years ago tried on the river Schuylkill by a farmer near Reading, but without success. From an exhibition of this plan it was that Mr Rumsey procured the certificate from General Washington, and on that certificate were Mr Rumsey's laws founded. In his petitions to the several legislatures, he prayed for no exclusive right for the use of steam-boats; neither did he make mention of steam to their committees, or even suggest an idea of the kind."—

Mr Miller of Dalswinton.

Patrick Miller, Esq. of Dalswinton, in Dumfriesshire, made many experiments on the best mode of impelling single, double, and triple vessels with paddle-

* *The Original Steam-Boat supported; or a Reply to Mr James Rumsey's Pamphlet, showing the true priority of John Fitch.* Philadelphia, 1788.

wheels, by the power of men and horses; and printed and circulated extensively an account of a *Triple Vessel and wheels*, in February 1787. In this Tract, he states,—" I have also reason to believe that the power of the *Steam-Engine* may be applied to work the *wheels*, so as to give them a quicker motion, and, consequently, to increase that of the ship. In the course of this summer (1787), I intend to make the experiment."

As the power of men produced only the slow motion of five miles *per* hour, Mr James Taylor, then residing in Mr Miller's family, and now at Cumnock, suggested the application of a steam-engine as the moving power; and he carried Mr Miller to the house of Gilbert Meason, Esq. St Andrew's Square, Edinburgh, to see the model of a *steam-carriage* invented by Mr William Symington of Falkirk. Mr Miller was much pleased with the model, and desired Mr Symington to make him a small steam-engine, to work a *twin* or *double* boat on Dalswinton Loch. The engine having been accordingly executed and put on board the boat, the experiment was made at Dalswinton in autumn 1788; and it succeeded so well, that Mr Miller commissioned Mr Symington to purchase a *gabert*, or large boat, at Carron, and to fit up a steam-engine on board of her, to make a trial on a larger scale. Every thing being completed, the trial was made on the Forth and Clyde Canal, in summer 1789, Messrs Miller, Stainton, Taylor, &c. being on board, and the result answered their most sanguine expectations.

Mr Symington.

From a manuscript *Memorial on Steam-Navigation*, drawn up by Mr Symington, with the perusal of which we have been favoured, we make the following extract:

" Mr Miller being then very much engaged improving his newly purchased estate in Dumfries-shire, and I also employed to construct large machinery for the use of the lead-mines at Wanlockhead, the idea of carrying the experiments, at that time, any farther, was entirely given up, till meeting with the late Thomas Lord Dundas of Kerse, who wished that I would construct a steam-boat for dragging vessels on the Forth and Clyde Canal, in place of horses. Agreeably to his Lordship's request, a series of experiments, which cost nearly L. 3000, were set on foot in the year 1801, and ending in 1802, upon a larger scale, and more improved plan, having a steam cylinder 22 inches diameter, and four feet stroke; a complete model of which, with a set of ice-breakers attached, may be seen (if not in Lord Dundas's house, Arlington Street) in the Royal Institution, London, which proved itself very much adapted for the intended purposes, as will appear from the following simple yet authentic narrative. Having previously made various experiments, in March 1802, at Lock No. 20, Lord Dundas, the great patron and steam-boat promoter, along with Archibald Speirs, Esq. of Elderslee, and several gentlemen of their acquaintance being on board, the steam-boat took in drag two loaded vessels, *Active* and *Euphemia* of Grangemouth, Gow and Espline masters, each upwards of 70 tons burthen, and with great ease carried them through the long reach of the Forth and Clyde Canal, to Port-Dundas, a distance of 19½ miles, in six hours, although the whole time it blew a very strong breeze right a-head of us; so much so, that no other vessels could move to windward, in the canal, that day, but those we had in tow; which put beyond the possibility of doubt the utility of the scheme in canals or rivers, and ultimately on open seas; though in this state of forwardness it was opposed by some narrow-minded proprietors of the navigation, under a very mistaken idea, that the undulation of the water occasioned by the motion of the wheel would wash and injure its banks: in consequence the boat was, with great reluctance, laid up in a creek of the canal, near Bainsford Draw-bridge, exposed for years to public view; where Henry Bell from Glasgow, who frequently inspected the steam-boat at Carron in 1789, did also particularly examine this; and afterwards, in conjunction with other gentlemen, in the year 1811, constructed the first steam-boat, Comet, to ply on the river Clyde, which was soon followed there by many more, and its use is now rapidly extending to different regions of the globe."

It is indisputable, therefore, that Mr Symington was the first person who had the merit of successfully applying the power of the steam-engine to the propulsion of vessels. The boat which he constructed was, like that proposed by Hulls, really a *Tug*. It is much to be regretted, that there existed not enterprise enough at that time in Scotland to encourage the ingenious artizan to repeat his experiments on the Clyde. All the subsequent improvements, however, in steam-navigation may be fairly traced to Mr Symington's attempt, and we cannot help thinking that he has a strong claim on the national gratitude. He is still alive, and we fear not in the most flourishing circumstances. Should the state decline rewarding such meritorious services, the opulent proprietors of steam-boats might well evince their liberality and discernment, by bestowing on him some recompence.

Mr Fulton.

Considering the importance to America of navigating her mighty rivers, it is not surprising that the application of the power of steam to the propulsion of boats should, by persevering efforts, have been first carried into successful practice in that continent. This was achieved by the activity and zeal of Mr Fulton, who appears evidently, however, to have derived all his primary knowledge of the subject from Scotland.

Mr Symington's *Memorial*, above referred to, gives the following remarkable statement:

" When engaged in these last experiments in 1802, I was called upon by Mr Fulton, who very politely made himself known, and candidly told me that he was lately from North America, and intended to return thither in a few months, but having heard of our steam-boat operations, could not think of leaving this country without first waiting upon me in expectation of seeing the boat, and procuring such information regarding it as I might be pleased to communicate; he at same time mentioned, however advantageous such invention might be to Great Britain, it would certainly become more so in North America, on account of the many extensive navigable rivers in that country; and as timber of the first quality, both for

Steam-Navigation.

building the vessels, and also for fuel to the engine, could be purchased there for a small expence, he was decidedly of opinion it could hardly fail, in a few years, to become very beneficial to trade in that part of the world; and that his carrying the plan to North America could not turn out otherwise than to my advantage; as, if I inclined it, both the making and superintendence of such vessels would naturally fall upon me, provided my engagements with steam-boats at home did not occupy so much of my time as to prevent me from paying any attention to those which might afterwards be constructed abroad.

"Mr Fulton having thus spoken, in compliance with his most earnest request, I caused the engine fire to be lighted up, and in a short time thereafter, put the steam-boat in motion, and carried him from Lock No. 16, where the boat then lay, four miles west the canal, and returned to the place of starting, in one hour and twenty minutes, to the great astonishment of Mr Fulton, and several gentlemen, who, at our outset, chanced to come on board.

"During the above trip, Mr Fulton asked if I had any objections to his taking notes respecting the steam-boat, to which question I said, none; as I considered the more publicity that was given to any discovery intended for general good, so much the better; and having the privilege secured by letters-patent, I was not afraid of his making any encroachment upon my right in the British dominions; though in the United States, I was well aware, I had no power of control. In consequence, he pulled out a memorandum-book, and, after putting several pointed questions respecting the general construction and effect of the machine, which I answered in a most explicit manner, he jotted down particularly every thing then described, with his own remarks upon the boat, while moving with him on board, along the canal; but he seems to have been altogether forgetful of this, as, notwithstanding his fair promises, I never heard any thing more of him, till reading in a newspaper an account of his death.

"From the above incontrovertible facts, which can be corroborated by a number of people of respectability living at this day, it is very evident that commerce is not indebted to North America for the invention of steam-packets, it being hereby established beyond the possibility of doubt, to be truly British, both in idea and practice, and that Mr Fulton's steam-vessel did not make its first appearance in the Hudson River earlier than 1806 or 1807, four years at least posterior to his having been on board the Charlotte Dundas steam-boat, and minutely examined it, when at work upon the Forth and Clyde Canal, and 18 years later than the date of the first experiments made by me upon steam-boats, on the lake at Dalswinton, Dumfries-shire, in Great Britain."

Mr Henry Bell.

The following statement upon the same point, by Mr Henry Bell of Glasgow, was addressed by him to the Editor of the *Caledonian Mercury*, and published in that paper in October 1816:—"Sir, I observed in your paper lately a paragraph respecting steam-boats, in which the Americans claimed the right to the discovery, which is become of so much utility to the public. On this account I propose to give you a full statement of what I conceive to be the truth. Mr Miller of Dalswinton first wrote upon the method of moving or impelling vessels or rafts through water by paddles, wrought by a capstan, or by the wind, in the manner of a wind-mill, which idea he afterwards gave to all the different Courts in Europe. It will be recollected by most people in this country, that the French proposed to erect rafts for conveying troops to invade this country by means of Mr Miller's wind-mill or capstan plan; for it may be stated that this gentleman built two vessels at Leith, and put them in motion upon his new improvement, and even sent one of them to the King of Sweden, as a present. After this, he thought that an engine could be so constructed as to be applied to work his machinery for the moving of his paddles; and accordingly he employed an engineer to put his plans in execution; but they failed for want of being properly executed.—But to give you a more correct account of the manner Mr Fulton, the American engineer, came to the knowledge of steam-boats, that gentleman had occasion to write me about the plans of some machinery in this country, and begged the favour of me to call on Mr Miller of Dalswinton, and see how he had succeeded in his steam-boat plan; and if it answered the end, I was to send him a full drawing and description of it, along with my machinery. This led me to have a conversation with the late Mr Miller, and he gave me every information I could wish for at the time; I told him where, in my opinion, he had erred, or was misled by his engineer; and, at the same time, I told him that I intended to give Mr Fulton my opinion on steam-boats: the friends of Mr Miller must have amongst their papers Mr Fulton's letter to me, for I left it with Mr Miller. Two years thereafter I had a letter from Mr Fulton, letting me know that he had constructed a steam-boat from the different drawings of machinery I had sent him out, which was likely to answer the end, but required some improvement on it. This letter I sent to Mr Miller, for his information, which must also be among his papers. This letter led me to think of the absurdity of writing my opinion to other countries, and not putting it in practice myself in my own country; and, from these considerations, I was roused to set on foot a steam-boat, for which I made a number of different models, before I was satisfied. When I was convinced that they would answer the end, I contracted with Messrs John Wood and Company, ship-builders in Port-Glasgow, to build me a steam-vessel, according to my plans, 40 feet keel, and 10 feet 6 inches beam, which I fitted up with an engine and paddles, and called her the *Comet*, because she was built and finished the same year that a comet appeared in the north-west part of Scotland. This vessel is the first steam-boat built in Europe that answered the end, and is at this present time upon the best and simplest method of any of them; for a person sitting in the cabin will hardly hear the engine at work. She plies on the Frith of Forth, betwixt the east end of the Great Canal and Newhaven, near Leith. The distance by water is 27 miles, which she performs, in ordinary weather, in 3½ hours up, and the same down. There were many attempts to make steam-boats in this country

before this one, but none of them ever answered the end; and even three years after the Comet was set a sailing, there was a number of our first rate engineers joined together, and obtained a patent for what they conceived a new discovery on the paddles for impelling the vessel forward. They were disappointed in their plan, and had to return to the mode of the Comet.'"—

The first American steam-boat which completely succeeded was launched at New York on the 3d October 1807 (five years before the construction of the Comet at Port-Glasgow), and soon after plyed between that city and Albany, a distance of 160 miles.

Rapid Progress of Steam-Navigation.

In Britain, steam-vessels were first brought into use in 1812 upon the Clyde. They were built at Port-Glasgow, Greenock, and Dumbarton, where the art of ship-building had for many years been conducted by carpenters eminent in their profession. When launched, they were towed at a very trifling expence up the Clyde to Glasgow, situated in the midst of inexhaustible mines of coal and iron, and where the number of skilful practical engineers and artificers rendered the construction of the engines and machinery easy, and the prices moderate.

The early experiments were, of course, made upon a small scale. The first steam-boat actually put to use there was the Comet (40 feet keel, $10\frac{1}{2}$ feet beam, 4 wheels, 4 shovel-shaped paddles on each, with a cistern of fresh water to feed the boiler), built, as already mentioned, by Mr Henry Bell. She had an engine of only three horses' power, being intended merely for passengers; who, till then, had no other means of conveyance on the river than small row boats, either quite open, or supplied with only an awning to secure them from the weather. Small as this engine was, it rendered the passage certain in one tide; the vessel being able to make head-way even against the wind, and in rough weather.

The success of the first experiment soon excited competition; and a larger vessel, the Elizabeth (58 feet on deck, 11 feet beam, with an engine of 8 horses power), was completed in March 1813, and for a time proved very profitable to the proprietors. The third boat, the Clyde, which began plying in July of the same year, was still larger in her dimensions; being 70 feet keel, 75 feet on deck, 13 feet beam, with an engine of 14 horse power.

At present there are about thirty-five steam-vessels on the Frith of Clyde, some of which sail from Glasgow almost every hour, or half-hour, during day-light, to the various ports on the river, and the lochs communicating with it; as Dumbarton, Helensburgh, Loch-Long, Rothsay, Loch-Fine, and Campbellton, on the right bank, and Port-Glasgow, Greenock, Gourock, Innerkip, Largs, Milport, Ardrossan, Ayr, Irvine, Girvan, Stranraer, &c. on the left bank. Many of them occasionally visit Islay, Mull, Staffa, Icolmkill, and adjacent islands, during the summer months; and also Londonderry, Coleraine, and other ports of Ireland. Several vessels of larger dimensions, are employed as regular packets to Belfast, the Isle of Man, Liverpool, &c., and thus a constant communication between the united kingdoms is maintained. Since 1821, two steam-vessels have regularly sailed from Leith to Aberdeen, calling at several of the intermediate ports. Five or six steam luggage-boats are constantly employed as lighters and draggers of other boats, for the speedy conveyance of goods from Glasgow to the ports of exportation, and occasionally towing large vessels in or out of harbour. The annual voyages of each of these 35 vessels may be averaged at 10,000 English miles; consequently, the whole sail 350,000 miles yearly, or nearly 14 times the circumference of our globe.

The success of steam-vessels at Glasgow soon excited attention in other quarters, and several of the Clyde vessels were purchased as models. It is worthy of mention, that shortly after the time of their appearance on the Clyde, Mr Lawrence of Bristol established a steam-boat on the Severn, and having carried her to ply on the Thames, the Company of Watermen made such opposition to this innovation, that he was obliged to take her back. Now, however, not only are all the chief navigable rivers in Britain thus navigated, but steam-vessels ply regularly from London to Aberdeen, sometimes passing the Pentland Frith.

On the Holyhead station, to carry mails between England and Ireland, there are three steam-vessels employed, viz. the Royal Sovereign, 210 tons, two 40-horse engines; the Meteor, 190 tons, two 30-horse engines; and the Ivanhoe, 165 tons, one 56-horse engine. They have answered the purpose much better than sailing vessels; as a proof of which, during the last year the latter were employed, exactly 100 Irish mails arrived in London *late;* while, during the nine months after the steam-boats were first established, only 22 arrived *late;* and that winter happened to be extremely boisterous. These boats use sails occasionally, and go to sea when sailing vessels dare not leave port. The average passage of the Royal Sovereign, from Houth to Holyhead, is six hours, fifty-seven minutes; from Holyhead to Houth seven hours, thirty-six minutes. Of the Meteor, from Houth to Holyhead, seven hours, four minutes, and back, eight hours, thirteen minutes. The average passage is half the time in which the average passage of sailing vessels used to perform the voyage. The shortest passage was from Houth to Holyhead, five hours, thirty minutes; which, the distance being about 73 miles, is nearly 12 miles an hour.

Speed of Steam-Vessels.

It is difficult to say what is the maximum speed of steam-vessels. Several of those between London and Margate make the voyage in seven hours and a half, a distance of 84 miles. The Hero made the voyage, wind and tide in her favour, in six hours, sixteen minutes. The Eclipse, from Belfast to Greenock, 120 or 130 miles, has been known to come in nine hours; and, on one occasion, having about 3000 square feet of canvas set, besides the engine at work, she came from Ailsa to Greenock at the rate of 9 miles. The Henry Bell, a new steam-trader between Glasgow and Liverpool, has delivered goods at various warehouses in Glasgow, several hours *before* the invoices, or advice of the shipment, had arrived *in course of post.* The New York steam-vessels run up

to Albany, 160 miles, in 21 hours, and down in 19; never in less than 19. They go from Newhaven to New York, 90 miles, in six hours and a half without sail; being nearly 14 miles *per* hour.

At present, steam-boats frequently ply between London and Dieppe, Rouen, Havre de Grace, Cadiz, Corunna, Alicant, Vigo, Lisbon, and other ports of France, Spain, and Portugal. One was lately established between Naples and Leghorn and Genoa; but soon abandoned, owing to the oppression of the quarantine laws, and the rapacity of the government of the Two Sicilies. Another steam-vessel was launched by an American gentleman on the Lake of Geneva, but, being a very bad sailer, it is about to be replaced by another. Every season they are becoming more numerous, and adventurous in sailing to greater distances and through heavier seas; such as the Bay of Biscay, the Mediterranean, the Baltic, the Gulfs of Finland, Bothnia, &c. A steam-packet, carrying the mail, now sails between Kiel, in Holstein, and Copenhagen. In the Adriatic, the Carolina goes every second day from Venice to Trieste, and the Eridano to Pavia; the latter voyage being usually accomplished in 37 hours. The Royal George steam-packet makes her passage from Portsmouth to Corunna in from 60 to 64 hours; a distance of between 400 and 500 miles.

Present State of Steam-Navigation.

Having thus endeavoured to give a sketch of the origin and progress of steam-navigation, we shall now proceed to describe the form and parts of a steam-boat (suppose of 100 tons), and to some other details, calculated to furnish a more particular view of the present state of steam-navigation in Britain and other countries.

Fig. 1, Plate CXVII., is an elevation; fig. 2, a longitudinal section; fig. 3, a ground plan; fig. 4, a transverse section. The same letters refer alike to the respective parts of each figure: A, the two boilers, with their two manhole doors, one to each; B, the chimney; C, the steam pipes; DD, the cylinders of the two engines; EE, the two air pumps; F, the side lever; one on each side of each engine; GG, the crank of the paddle-wheel shaft; H, the rod that works the steam valves or hand gear, moved backward and forward by an eccentric wheel on the shaft; I, the nozzles; K, pillars of the framing; LL, the area where the fireman stands to put coals into the furnace; MM, place where the coals are stowed away; NN, the paddle-wheels and covers: O, ladies' parlour; P, principal cabin; Q, second cabin; having each a raised lantern or sky-light, besides the lateral windows of P and Q; R, steward's room; S, breakfasting room; TT, refreshment rooms for the second cabin passengers: U, small boat ready to be let down on an emergency; V, rudder; WW, seamen's beds; XX, space for lumber or spare fuel. The fireman stands in the space LL; an iron trap-ladder leads down to it from the deck, flush with which are two horizontal gratings for the admission of fresh air to himself and the fire; his coals are built up behind him, and he brings down only a few lumps at a time, which he breaks into small pieces as required. The chimney B is a series of sheet-iron cylinders rivetted at the joints, and slipt the one over the other. Each boiler has a flue within, making various convolutions under the surface of the water; through which the smoke and flame pass, until they enter the chimney.

These wheels being ponderous, acquire sufficient momentum to turn the crank, and supersede the necessity of a fly. The air-pump, feed-pump, and occasional cold water-pump, are wrought by rods from FF, the side horizontal levers. To prevent the waste steam of the boilers from annoying the passengers, a pipe conveys it into the chimney. Besides this, a waste steam valve is within reach of the engine-man, who loads and unloads it as he finds necessary. It is a curious fact, that a great flow of steam into the chimney prevents black smoke from issuing from it, which otherwise would. The paddle-wheels are firmly wedged on their shaft, and whatever pressure they exert against the water causes an equal re-action on the vessel, which is thus impelled either forwards or backwards according to the direction of circumvolution.

The principal cabin is painted, and otherwise tastefully fitted up, and furnished with a stove, the chimney of which rises up through the deck. The second cabin occupies the fore-end of the vessel, and is also completely furnished, less elegantly. Small steam-boats from 30 tons upwards are generally laid out much in the same way, only varying according to the nature of their employment. When intended for sea voyages, a great part of the internal space is allotted for sleeping births.

Plate CXVI. exhibits a sketch of one of the Clyde vessels, the *City of Glasgow*, of 300 tons.

The following is an alphabetical list of steam-vessels built in Britain:

When Built.	Names of Vessels.	Tonnage.	Engines.	Horse Pow.
1822	Aaron Manby .	140	1	28
1821	Abbey . :			
1819	Active . . .	83	1	10
1816	Ætna (double vessel)	75	1	20
1820	Aire and Calder .	110	1	35
1816	Albion . .	92	1	22
1818	Albion . .	75	1	24
1822	Albion . .	160	2	60
1815	Argyle . .	88	2	32
1821	Arrow . .	130	2	40
1820	Belfast . . .	190	2	70
1821	Brilliant . .	160	2	40
1822	Bristol Cambria .	100	1	30
1818	British Queen	75	1	20
1817	Britannia .	70	1	15
1820	Britannia .	100	2	40
1821	Britannia .	80	1	20
1815	Caledonia . .	102	2	32
1816	Caledonia . .	80	1	12
1820	Caledonia . .	80	2	30
1821	Caledonia . .	84	1	30
1821	Cambria . .	130	2	50
1813	Clyde . .	69	1	14
1821	City of Edinburgh .	400	2	80
1822	City of Glasgow .	300	2	100
1818	Cobourg	75	1	24

When Built.	Names of Vessels.	Tonnage.	Engines.	Horse Pow.
1812	Comet	25	1	3
1821	Comet lengthened	70	1	30
1816	Congo	100	1	20
1819	Countess of Scarborough	50	1	10
1821	Dasher	130	2	40
1817	Defiance	50	1	14
1820	Diana	60	2	20
1818	Dispatch	83	1	10
1820	Duchess of Northumberland	40	1	10
1822	Duke of Lancaster	141	2	50
1818	Dunbarton	100	1	16
1814	Eagle (double vessel)	40	1	6
1816	Eagle	70	1	20
1821	Eagle	170	2	40
1819	Eclipse	190	2	60
1821	Eclipse	140	2	60
1821	Edinburgh Castle	148	2	40
1813	Elizabeth	40	1	10
1823	Emerald Isle	450	2	65
1818	Engineer	315	2	70
1817	Enterprise	30	1	5
1820	Earl of Egremont	50	2	24
1818	Favourite	160	2	40
1819	Favourite	117	1	26
1817	Fingal	67	1	16
1813	Glasgow, now the Thames	74	1	16
1820	Glasgow	90	1	24
1819	Gourock	65	1	14
1817	Greenock	52	1	10
1823	Henry Bell	200	2	60
1822	Hercules	130	2	60
1821	Hero	233	2	90
1823	Hibernia	280	2	40
1821	Highlander	67	1	24
1822	Highland Chieftain	65	1	16
1820	Highland Lad	51	1	12
1815	Hope	45	2	6
1819	Hope	30	1	6
1817	Humber	80	1	12
1820	Indefatigable	30	1	8
1818	Industry	79	1	10
1820	Inverary Castle	114	2	40
1820	Ivanhoe	165	2	56
1821	James Watt	448	2	100
1817	John Bull	75	1	15
1822	King of the Netherlands	140	2	80
1814	Lady of the Lake	76	1	20
1818	Lady of the Shannon	90	1	20
1821	Lady Stanley	87	1	20
1819	Largs	96	1	35
1820	Leeds	125	1	30
1822	Lemington Packet	30	1	7
1817	London	70	1	14
1822	Lord Melville	220	2	80
	Lord Nelson, see Sir William Wallace			
1816	Majestic	90	1	24
1821	Majestic	350	2	100
1819	Maria Tug	80	1	24
1817	Marion	70	1	14
1813	Margery	70	1	14
1818	Marquis of Bute	60	1	14

When Built.	Names of Vessels.	Tonnage.	Engines.	Horse Pow.
1822	Medina	100	1	36
1822	Medusa	90	2	20
1819	Mersey	80	1	24
1819	Mersey	60	1	20
1821	Meteor	190	2	60
1814	Morning Star	100	1	26
1814	Morning Star	20	High pres.	3
1821	Mountaineer	190	2	70
1821	Navigator	40	1	18
1816	Neptune	88	2	40
1813	Orwell	60	2 Horiz.	12
1813	Orwell	20	High pres.	3
1815	Oscar	70	1	12
1814	Perseverance	60	1	14
1814	Phœnix	25	High pres.	4
1821	Postboy	80	1	20
1819	Port Glasgow	70	1	16
1821	Portuguese	80	2	20
1813	Prince of Orange	40	2	8
1822	Prince Llewellyn	170	2	70
1821	Queen Margaret	60	1	20
1823	Quentin Durward	96	2	40
1821	Rapid	140	2	56
1822	Rapid	140	2	60
1816	Regent	112	2	24
1814	Richmond	60	1	10
1818	Rising Star	400	2	70
1819	Robert Bruce	155	2	60
1819	Robert Burns	73	1	24
1818	Rob Roy	100	1	30
1820	Rothesay Castle	90	1	24
1823	Royal George Ship		2	
1821	Royal Sovereign George IV.	210	2	80
1822	Royal Sovereign	220	2	80
1821	Safety	36	1	14
1821	Sampson	100	2	40
1818	Selby	80	1	24
1822	Sir Joseph Yorke	100	1	30
1816	Sir William Wallace, formerly Lord Nelson	95	2	32
1823	Soho	510	2	120
1818	Speedwell	40	1	10
1814	Stirling Castle	60	1	12
1817	Sons of Commerce	80	1	20
1822	Sovereign	95	2	32
1822	Sovereign	95	2	32
1822	St George	312	2	110
1822	St Patrick	298	2	110
1821	Star	90		
1820	Superb	246	2	70
1821	Surprise	120	2	30
1815	Swift	12	1	3
1819	Swift	9	1	3
1821	Swift	250	2	80
1821	Swiftsure	104	2	30
1819	Talbot	156	2	60
1821	Tartar	180	2 Horiz., 1 Vertical.	80, 10
1821	Thames, see the Glasgow			
1821	Thane of Fife	148	2	40
1822	Tourist (now Royal George)	200	2	80
1822	Towart Castle	120	2	50
1818	Trusty	88	1	10

When Built.	Names of Vessels.	Tonnage	Engines.	Horse Pow.
1817	Tug	95	2	32
1820	Two Brothers	35	1	9
1820	Tyne	40	1	10
1821	Union	20	1	4
1822	Union	53	2	16
1822	Union, double ferry-boat	100	2	30
1821	Venus	265	2	60
1821	Velocity	150	2	40
1818	Victory	160	2	40
1820	Waterloo	90	1	20
1819	Waterloo	210	2	60
1822	Yorkshireman	200	2	80

The Soho, the largest vessel in this list, indeed the largest steam-vessel yet built in Europe, was launched in July 1823, intended to ply between Leith and London, a distance of about 460 miles. She is impelled by two engines of 60 horse power each; her length of deck is 163 feet; breadth 27; depth of hold 16 feet, 10 inches; burden 510 tons. Her accommodations are extensive, having space for 112 beds. The ladies' cabin is eight feet high.

The Soho is, however, of somewhat smaller dimensions than the American steam-boat, the Chancellor Livingston, plying on the Hudson river between New York and Albany, constructed by Mr Fulton. The following are some particulars respecting this vessel. Her keel is 154 feet long; deck 165; 32 broad; burden 520 tons; draft of water about seven feet three inches; principal cabin 54 feet long, 7 high; ladies' cabin, above the other, 36 long, with closets; forward cabin 30 long, 7 high. Permanent sleeping-births, in principal cabin, 38; in ladies' cabin, 24; in fore cabin, 56; in captain's cabin on deck, 2; engineers' and pilots', 3; forecastle, 6; fire-men, cooks, &c., 6; total, 135. Her engine is of 75 horse power; diameter of cylinder 40 inches, length five feet; piston rod, $8\frac{1}{2}$ feet; stroke, five feet; boiler, 28 feet long, 12 broad, with two funnels; paddle-wheels, 17 feet diameter; paddle-boards five feet, ten inches long, with two fly-wheels, each 14 feet diameter, connected by pinions to the crank wheel. The machinery rises $4\frac{1}{2}$ feet above the deck. Average rate of sailing eight and one-half to eight and three-fourths miles an hour. With a strong wind and tide in her favour, she has made twelve; but with a strong wind and tide, against her, not more than six miles *per* hour. The hands employed on board are—13 mariners, 11 cooks, waiters, stewards, &c.;—in all 24.

This vessel, however, is still much surpassed in size by the Lady Sherbrooke, of 787 tons, and 60 horse power; being the largest of eight which ply on the river St Lawrence. This gives 13 tons for each horse power, whereas in the Soho the same burthen has three times as much action applied to it. The American steam-vessels, though fast sailers, are thus impelled by comparatively smaller engines than those built in this country.

It appears from the *Report of the Select Committee of the House of Representatives*, for session 1817, that there were then 17 large steam-boats in constant employment on the American rivers, besides ferry-boats. But since that time they have increased so rapidly, that there are now (1823) about 300.

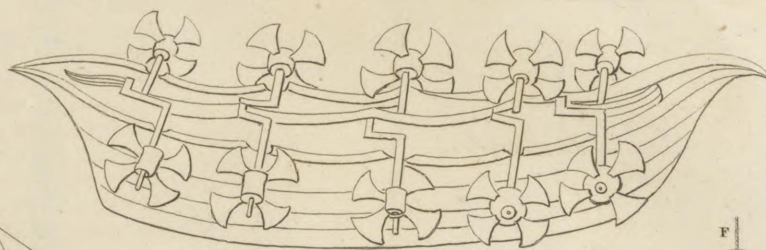
The following are the names of 35 vessels, and their tonnage, plying on the Mississippi and its tributary rivers alone, viz. Alabama, 200 tons; Buffalo, 300; Cedar Branch, 250; Cincinnati, 120; Constitution, 75; Eagle, 70; Etna, 390; Exchange, 200; Experiment, 40; Frankfort, 320; General Jackson, 200; General Pike, 250; Governor Shelby, 120; Harnot, 40; Hecla, 70; Henderson, 85; Independence, 300; James Monroe, 90; James Ross, 320; Johnston, 80; Kentucky, 80; Louisiana, 54; Madison, 200; Maysville, 150; Napoleon, 332; Ohio, 443; Paragon, 400; Rifleman, 250; Rising States, 150; St Louis, 220; Tamerlane, 320; Vesta, 100; Vesuvius, 390; Volcano, 250; Washington, 400;—in all 7259 tons.

Belonging to some of the States, there are steam frigates and ships of war carrying guns, some of them 100 pounders. These vessels are 13 feet thick in the sides, of alternate layers of oak and cork; are so constructed, that they can eject boiling water on their enemies; and there are cases of cutlasses and pikes which project from their sides, and draw back again every fifteen seconds.

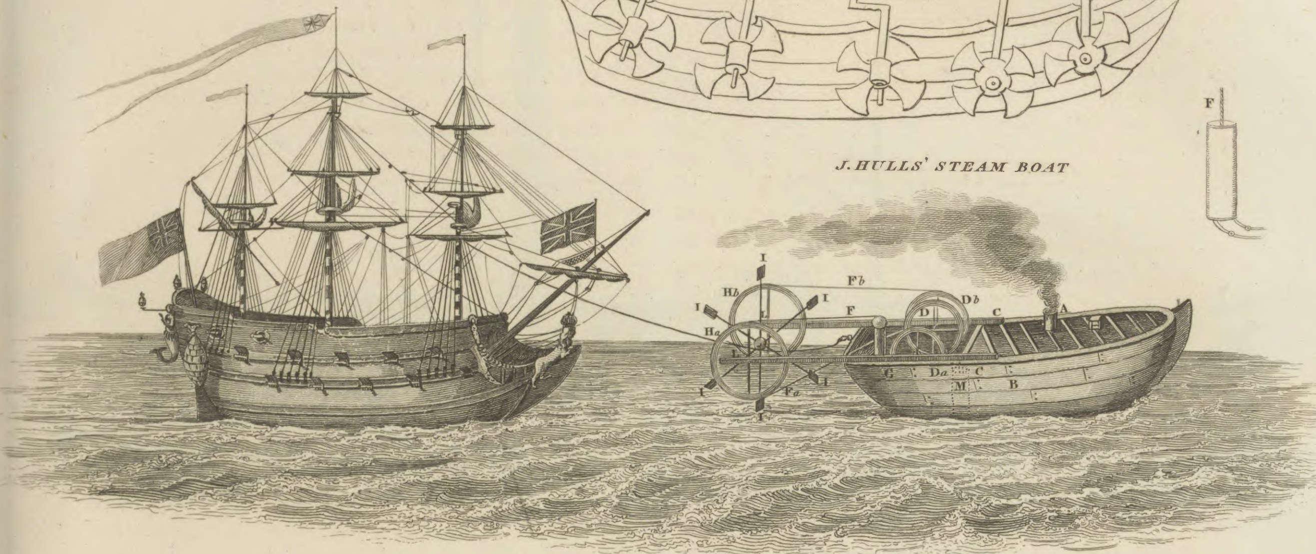
The Savannah, of 350 tons, was the first steam-vessel that crossed the Atlantic. She arrived at Liverpool 20th June 1819, in 21 days from land to land; 18 of which her engine was going; her daily consumption of coal was about 10 tons, so that she must have had at least 200 on board, leaving 150 for the weight of engine and cargo. Her paddles were occasionally taken off, when she sailed by wind and the whole of the paddle-wheels were capable of being taken to pieces and shipped, in case of bad weather. As the distance is not much short of 4000 miles, she must have averaged nearly 200 *per* day.

By far the greatest number of steam-vessels use low pressure engines. A larger proportion of American vessels have high pressure engines than in this country. High pressure engines are wrought with steam of a great variety of strengths, from 30 to 160 lbs. *per* square inch. Some engineers assert, that it is capable of being used at 1000 lbs. The steam is not condensed, but, after having acted on the piston, is allowed to blow off into the air. The diameter of their steam cylinders may be made of any size proportioned to the strength of the steam used. Thus, when it is 160 lbs., the area of the cylinder may be only a sixteenth part of the area of one using steam of 10 lbs.; consequently, a five inch cylinder wrought with such strong steam will be equal in power to a 20 inch cylinder wrought with such weak steam. High pressure engines require neither air-pump, conductor, nor the parts therewith connected; and as the volume of steam used is in proportion, their boilers may consequently be much smaller. Hence these engines occupy less room and tonnage, and require somewhat less fuel; but the risk of explosion is considerable. Were it otherwise, they would be very valuable at sea, because their power can be *increased* on emergencies, by merely increasing the fire, whereas the power of condensing engines is much more circumscribed, and confined to their original construction. The free effective power of large

BOAT OF 15TH CENTURY PROPELLED BY PADDLE WHEELS



J. HULLS' STEAM BOAT



SKETCH OF THE CITY OF GLASGOW STEAM BOAT

Published by A. Constable & C^o. Edin^r. 1824.

Eng^d. by W.H. Lizars

Fig. 1.

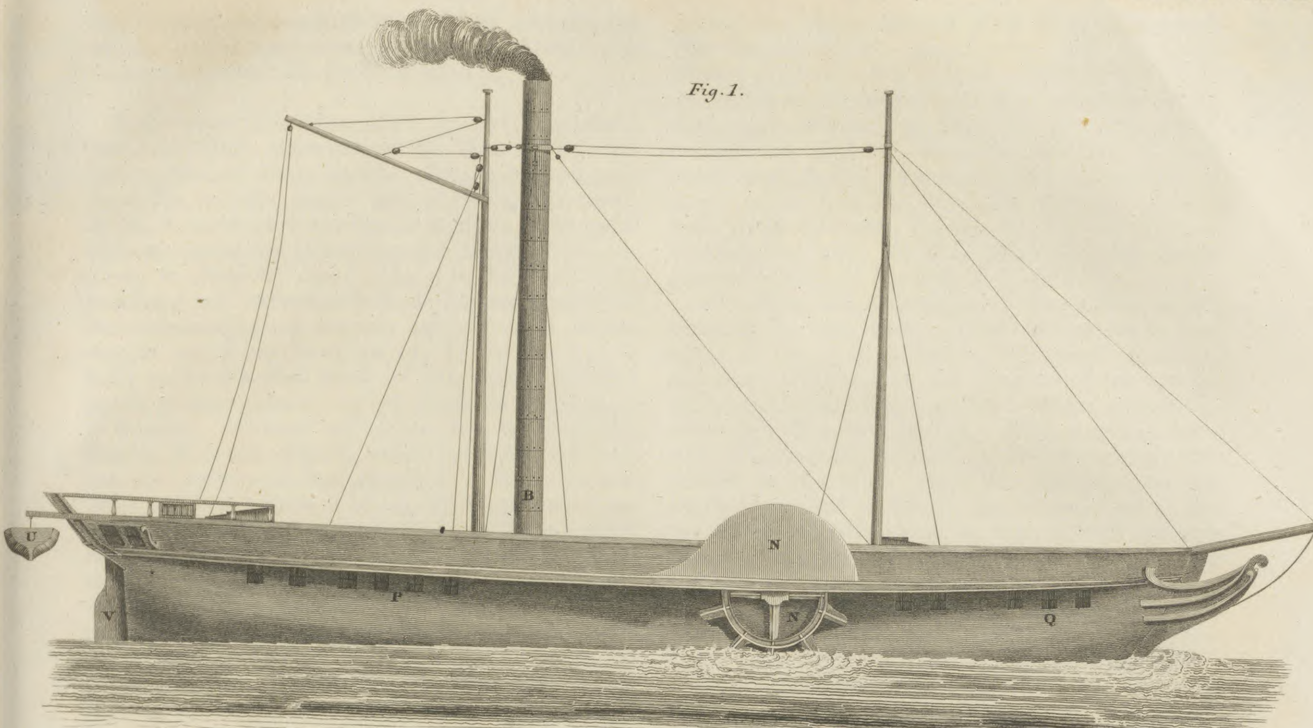


Fig. 4.

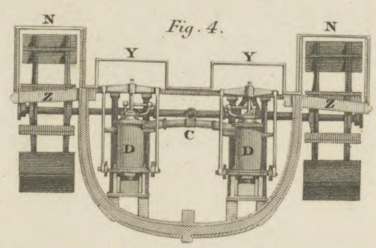


Fig. 2.

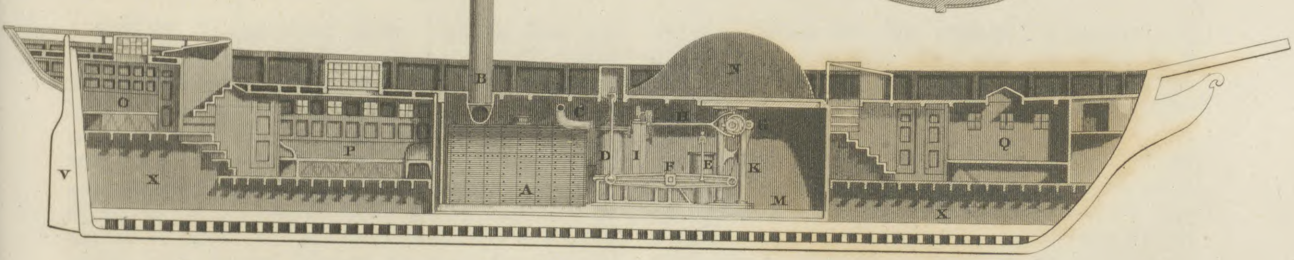
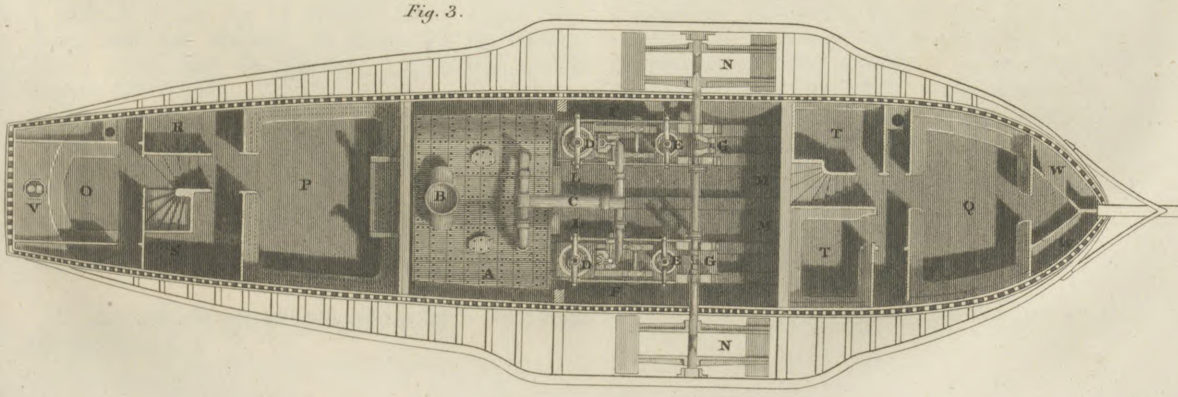


Fig. 3.



Scale of 10 5 0 10 20 30 40 *Feet*

Eng.d by W. H. Lizars

Published by A. Constable & C.o 1824

Steam-Navigation.

low pressure engines is about eight or nine lbs. *per* square inch of their steam pistons, and of small ones under 30 horses, only seven or eight.

General Observations as to the Improvement of this Art.

It is remarkable that, after the first successful trial, very little improvement has been made in the construction of steam-vessels. Experience has only fixed the suitable proportions of the several parts. Much, however, still remains to be done. The great objects wanted are to increase the power of the engine; to avoid the waste of force in the play of the paddles; and to render their action more equable. Notwithstanding the number and variety of steam-engines which have been erected in this island, it is truly surprising that some of the most important points of theory should be left uncertain and subject to dispute. We have neither ascertained exactly the density of steam formed under different pressures, nor the quantity of heat absorbed in its formation. Most of the conclusions of engineers are drawn rather from analogy than from facts; and a new set of experiments on steam, conducted with scrupulous attention, and on a comprehensive plan, are much wanted at present to guide all our practical operations. It seems probable that the most economical engines, on the whole, are those which work under a high steam pressure, though the statements given by different authors cannot be easily reconciled. The vapour of other fluids has sometimes been proposed instead of the steam from water. It would be an important object gained, if the same elastic force could be created with less expence of heat. The prodigious consumption of coals by the boilers proves a great hindrance to the extension of steam-navigation. The store of this ponderous species of fuel required for the supply of the engine in a distant voyage, would occupy the whole tonnage even of a large vessel. The Rapid, of 130 tons burden, and 60 horse power, required nearly a ton of coals every two hours, and could not therefore continue at sea above eleven days; and we have seen that the Savannah, which crossed the Atlantic, consumed ten tons of coals every day, or 210 tons during the passage of 21 days, leaving only 140 of surplus tonnage. Unless some great discovery, indeed, be made on the concentration of heat, we shall never dispatch steam-packets directly to the East or West Indies.

Steam-Navigation || Steel-Engraving.

The form and disposition of the paddles might certainly be improved. They seldom strike the water in the right direction, but splash it about, and leave it to impede the progress of the vessel. An irregular unpleasant motion is hence produced, and much force thereby lost. With a strong side-wind likewise, the larboard paddles are deeply immersed in the water, while the opposite ones are nearly suspended in the air, and scarcely act at all; the necessary consequence is, that, in such circumstances, the steam-vessel describes a winding path, and becomes unmanageable by the helm. Is it not possible to apply the immediate power of steam to propel vessels without dividing and diminishing its action by the intervention of a train of cranks and paddles?

Steam-navigation, though still limited in its operation, is a splendid triumph of ingenuity, and constitutes an epoch in the history of the mechanical arts. It has opened a most beneficial internal commerce in the vast regions of America; it has wonderfully facilitated the communication between the different parts of Europe; and by multiplying the friendly intercourse of men in all countries, it has essentially contributed to diffuse knowledge, to soften prejudices, and to quicken the efforts of general industry.*

Steel-Plate Engraving.

STEEL, Engraving upon. At the first discovery of the Art of Printing from engraved metals, experiments would most probably be made with a view of ascertaining the fittest metal for the purpose; indeed it is known, that copper, tin, and silver, were employed by the early artists; and there are some prints, by Albert Durer, which are considered to be impressions from plates engraved or etched on steel. In the collection of Albert Durer's prints, in the British Museum, there are five of these prints, the chief of which are, *Christ in the Garden*, a print 6 inches by 8½ inches, dated 1515; the *Lady and the Monster*, 12 inches by 8¼ inches, dated 1516; and the *Cannon*, 12¾ inches by 8½ inches, dated 1518.

But, for the usual purposes of engraving, copper has some advantages which have led to its being nearly always employed in preference to other metals; and in one instance only have we found that steel plate was used for engraving upon in this country, before the late attempts to prevent the forgery of bank-notes. The plate we allude to is the "*Ceiling of the Star Chamber*," in the *Topographical Illustrations of Westminster*, engraved by Mr J. T. Smith, in 1805.

The great expense of renewing plates for bank-notes, when any superior engraving is introduced, for rendering imitation difficult, suggested the idea of employing a harder material than copper to engrave upon. Steel plate was tried, and found capable of affording from 20 to 30 times the number of impressions that could be obtained from a plate of copper; while it was not much more difficult to engrave upon. The advantage to be derived from employing steel was first made public, in this country, in 1818, by the inquiry respecting the prevention of forgery, instituted by the *Society for the Encouragement of Arts*, &c. in London; when a specimen of engraving on soft steel was presented to the Society by the late Mr Charles Warren; and

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* This Article was written mostly by a Gentleman of Glasgow, well informed on the subject of Steam-navigation.—Ed.

Steel-Engraving.

it appeared, from evidence collected by the Committee, that notes, with ornamental borders, printed from steel plates, were then in use, in America. Soon after this period, Messrs Perkins and Fairman, from America, in conjunction with Mr Heath, an eminent engraver of London, formed an establishment for printing notes, and other engravings, from steel blocks.

The methods of engraving on steel, adopted by Warren and others, were similar to those employed in engraving on copper; differing only so far as was necessary on account of the nature of the material, and the process of hardening the plates. In addition to these methods, Perkins, Fairman, and Heath, employ a mechanical process for increasing the number of impressions. They first make the engraving on a thick plate of soft steel; the plate is then hardened, and the impression is transferred, in a spring press, to the surface of a soft steel cylinder, by rolling the cylinder repeatedly to and fro on the engraved plate, under a very considerable pressure. The transfer thus obtained is in relief, and the cylinder being hardened, it is made, by the same spring press, to repeat as many impressions as may be desired on soft steel, or on copper plates, for the purpose of printing from. They usually impress steel blocks, each of which will afford several thousand impressions, and when the cylinder becomes worn by transferring, a new one may be impressed from the original engraving; and, consequently, an inconceivable number of prints may be obtained from one original plate.

It ought, however, to be remarked, that an engraving cannot be transferred from steel to steel without injury; and that the injury will be greater in proportion to the spirit, freedom, and delicacy of the work. Indeed, where engravings are to be considered as works of art, it will always be preferable to engrave or etch on tempered steel, and print from it without hardening. A sufficient quantity of impressions may thus be obtained, and of a superior kind; because steel being more compact and hard than copper, it requires less labour to clean off the superfluous ink, and it is, consequently, less worn by this part of the process.* But the power of transferring is of great value in all cases where a great number of impressions is the chief object desired; as in notes, plates for school-books, ornamental borders for pottery, labels, &c.

In preparing steel plates, for either engraving or etching, the surface should be well polished, so as to render it compact, of an equable degree of hardness, and perfectly smooth. The same tools are used as for copper, but they should be of the kind of steel which is endowed with the greatest degree of hardness and toughness. When a plate is to be etched, the point which removes the varnish should be sufficiently hard to penetrate the polish on the surface of the plate; the acid will then bite more freely and to a greater depth, without spreading so as to produce a broad and shallow line. A point of diamond is, we believe, sometimes employed, particularly where the lines are drawn with the *ruling-machine,* invented by Mr Wilson Lowry, the founder of a new school of engraving, which has been of infinite use in diffusing correct taste in architecture and sound knowledge in mechanics. The same ingenious artist observed, in the first etchings on steel, that the lines were broad without depth; and, in consequence, tried to find a *menstruum* that would answer the purpose better than the common acids; in this he perfectly succeeded, and was enabled to bite the lines deep, and yet preserve the desired degree of fineness. This discovery he subsequently disposed of to Mr Heath: the exact nature of the process we have not been able to ascertain.

Of the common acids, diluted muriatic acid seems to answer best, but diluted nitric acid produces nearly the same effect.

When the plate is not to be hardened after being engraved, one of a spring temper may be employed; and if etching only is to be done on the plate, thin steel of a harder temper might be used; but the hardness must not be greater than will admit of its being scratched by the tracing point; otherwise a fine line cannot be produced of the necessary depth.

When the graver is to be much employed on a plate, it should be annealed (see Annealing in this *Supplement*), in order to render it uniformly soft. The plate, after being engraved, may be hardened most effectually, and with the least injury to the engraving, or risk of warping the plate, by heating it in a metallic bath, and quenching the whole in a cooling fluid. A bath of the fusible alloy of lead, tin, and bismuth, which Dr Wollaston proposed for hardening delicate steel-work, will, perhaps, answer better than any other. (See Cutlery, p. 457, Vol. III. of this *Supplement*.) It will always be an advantage to employ a perfectly fluid medium for cooling; and we have reason to conclude, from some hasty experiments, that water heated to its boiling point is better than cold water for cooling steel: the quick abstraction of heat, by converting water into steam, seems to have more effect than the mere cooling power of a large body of cold water.

If plates are not to be transferred, there is some disadvantage in employing thick ones; and more especially in cases where an alteration may be necessary, or a mistake is to be rectified. In a thin steel plate it is as easy to rectify an error as in copper; but in a thick one it is a troublesome process.

Mezzotinto engraving on steel is also found to answer equally as well as the other kinds; some very fine prints have lately been done in this manner; and the great number of impressions a steel plate affords, will cause this beautiful style of engraving to be more generally cultivated.

The advantages of copper consist in its being

* A steel plate, which had not been hardened, has been known to afford 95,000 impressions without material injury.

Steel-Engraving || Stirlingshire.

more easily prepared for engraving upon; in its softness, which renders it less difficult to engrave; and in the small degree of care necessary to protect the plate from injury, whenever it is not necessary to print at once the whole number of impressions the plate will afford. Now, it will always be difficult to preserve steel plates without more care and attention than can at all times be ensured; hence, each metal has its peculiar excellence; steel for the supply of a rapid and extensive demand; copper for the slow and regular progress of works on the sciences and arts.

As printing from engraved steel is now much used as a means of preventing forgery, we shall close this article with a few remarks on that subject. It appears to us, that there should be nothing complex in the figures that are selected for the engraving; their excellence should consist in the perfect evenness and parallelism of lines, whether straight or curved; but curved lines of difficult kinds should be preferred. Many crossings render a pattern intricate and confused: they distract the attention and dazzle the sight. Wavy patterns, with scattered lights, have the same effect. In such cases it is difficult to compare one specimen with another; and a general imitation is not so easily detected. It will be desirable to unite the work of an artist to that of a mechanical engraver; and in such cases the subject should be of sufficient size to allow of its being distinctly made out; because it will increase the difficulty of imitation. Where the circulation of notes is limited, good engraving on the note will be an effectual check upon forgery; but the notes of different banks should be made as distinct as possible, instead of the same work being introduced in different notes, as may easily be done with steel cylinders. Where a whole empire is served with one kind of notes, the temptation to forge is so great that it cannot perhaps be altogether prevented; and, therefore, while every proper expedient should be used to increase the difficulty of forgery, no apparent difficulty of copying should render bankers and others less on their guard against it.

See *Report of the Committee of the Society of Arts, &c. on the Mode of Preventing the Forgery of Bank-Notes*, 8vo. London, 1819. *Edinburgh Philosophical Journal*, Vol. III. p. 140. (H. H. H.)

STEREOTYPE PRINTING. See the Article PRINTING in this *Supplement*.

Situation and Boundaries.

STIRLINGSHIRE, a county in Scotland, situated between 55° 55′, and 56° 17′ north latitude, and between 3° 17′, and 4° 40′ west longitude, on the isthmus between the Friths of Forth and Clyde. It has the counties of Perth and Clackmannan on the north, the Frith of Forth and Linlithgowshire on the east, Lanarkshire on the south, and Dunbartonshire on the south-west and west; and, extending from 12 to 17 miles from north to south, and about 35 from west to east, contains 645 square miles, or 412,800 English acres; divided into 21 entire parishes, with portions of other four, which partly belong to the adjoining counties. The river and Frith of Forth is, for the most part, the boundary on the north, though one entire parish, and parts of other two are on the north side of that river; on the west it includes part of Lochlomond, and a narrow neck runs out on the north-west, the east side of which touches Loch Katrine. Like many other of the Scottish counties, it is of a very irregular form, yet most of its outline is well defined. Besides the Forth on the north and north-east, the Avon marks its separation from Linlithgowshire, on the east and north-east; the Kelvin flows along a great part of the southern boundary; and the Endric, before entering Lochlomond, divides it for some distance from Dunbartonshire on the west.

Extent.

Surface.

About two-thirds of Stirlingshire consist of hills unfit for cultivation, but affording good pasturage for sheep; being chiefly covered with green herbage, though sometimes intermixed with heath. The principal tract of this description, called the Lennox Hills, runs across the county, from Dunbartonshire on the west, to the town of Stirling on the north, but it seldom presents an elevation of more than 1500 feet. In other quarters, however, the elevation is greater; Benlomond, on the north-west, on the banks of Lochlomond, being 3262 feet high; and Bencloch, in the parish of Alva, on the north side of the Forth, upwards of 2400 feet. On the north, and still more on the east of the Lennox Hills, the country is low; the summit level of the Forth and Clyde Canal, which passes through the south-eastern side, being only about 162 feet above the sea, and much of the land along the Forth is a very rich plain, only a few feet higher than the water. Towards the western and southern extremities the surface is more varied, presenting tracts of heath, moss, and green pastures, intermixed with cultivated land; the latter confined, for the most part, to the banks of the streams.

Soil.

Stirlingshire has every variety of soil common in Scotland; but that for which it is chiefly distinguished in this respect is the alluvial or *carse* land on the Forth; which is computed to extend to about 40,000 English acres within this county, and twice as much more in the adjoining counties of Perth, Clackmannan, and Linlithgow, or, in all, to about 200 square miles; certainly by far the richest tract in Scotland. It consists of the finest particles of earth, without stones; in point of friability approaching to the character of loam; in some places 30 feet deep, and seldom more than 25 feet above the level of the sea at high water; and contains beds of shells, moss, and clay marl. In one instance, at the depth of 19 feet, there have been found in a stratum of moss the roots of large trees, deer's horns, and bones, while the superior strata were composed entirely of fine earth.

Minerals.

Coal, limestone, ironstone, and sandstone, abound in this county. Coal has not been found to the north and west of the Lennox Hills, but prevails very generally along their southern base, from Baldernock on the west to Denny and St Ninian's on the east; and generally throughout all the eastern quarter, on both sides of the Forth and Clyde Canal. By means of the Union Canal carried from the city of Edinburgh to the Forth and Clyde near Falkirk (see EDINBURGHSHIRE in this *Supplement*), these extensive coal-fields have been rendered of easy access to the metropolis, which already receives large supplies of coal from that quarter at little more than two-thirds of the price which the inhabitants formerly paid for this neces-

Stirlingshire.

sary article. Limestone abounds in the same quarters with the coal, and in many instances there is one stratum of it above, and another below the coal, the former always of the best quality. Sandstone also frequently accompanies both, though it is found in other parts. At Kilsyth there is a quarry of white sandstone, which takes a fine polish, and has been often used in ornamental work. Ironstone is in great abundance throughout the coal district, and is wrought in several places to a considerable extent, chiefly for the use of the Carron works. It is also found in the parish of Kilsyth, in balls from a quarter of an inch to a foot in diameter, which are richer in metal than the common stone. Copper has not been discovered in veins so rich as to encourage their working, though mines were formerly opened at one or two places. Veins of silver were discovered, about sixty years ago, in the parishes of Logie and Alva, on the northern extremity of the county, and for a few weeks the working was very successful, but was soon abandoned. Cobalt was found in the same quarter. There are indications of other minerals in different parts of the county.

Rivers.

Besides the Forth, the Avon, the Kelvin, and the Endric, already mentioned, which, though having their sources in Stirlingshire, soon cease to belong to it exclusively, flowing for the most part on its boundaries, this district is well supplied with other streams, which traverse its interior. The Forth, however, is by far the most important. It rises from a spring on the northern side, and near the summit of Benlomond; after a course of eight or ten miles, under the name of the Water of *Duchray*, it passes into Perthshire, where it is called *Avendow*, or Black River; and soon after, on returning to the borders of this county, obtains the name of the Forth. A few miles above Stirling it receives the Teith, and afterwards the Allan, from the north, and Bannockburn from the south. The tide, which flows a little above Stirling, renders it navigable to that town for vessels of 70 tons. Below Stirling the river winds in a remarkable manner across its valley, making so little progress, that, following its course to Alloa, the distance is about twenty miles, while in a direct line it is scarcely seven. These windings are called the *Links* of the Forth. Below Alloa it receives the Devon from the north-east, and soon after expands into the large estuary called the Frith of Forth, which washes the north-eastern side of the county till it meets with Linlithgowshire, a little to the south of Grangemouth. Next in importance, and the only other stream worthy of particular notice, is the Carron, which, rising in the interior, pursues an easterly course, and joins the Frith of Forth at Grangemouth. It is navigable for vessels of 200 tons, as far as the village of Carron Shore, the shipping place of the Carron Company, nearly two miles from its confluence with the Forth. Besides Lochlomond, of which the greater part is in Dunbartonshire, several small pieces of water occur in different parts, none of them remarkable. Salmon are caught in the Forth, and also in Lochlomond, and, some years ago, afforded a revenue of L. 1200 or L. 1400 a year to the town of Stirling; but they are not now so numerous as formerly.

The Forth.

Stirlingshire.

Valuation and Rental.

The valued rent of Stirlingshire is L.108,509, 3s. 3d. Scots, and the real rent of the lands and houses in 1812 was L. 207,236, 8s. 8d. Sterling. In 1811, the number of estates was 147; of which 109 were below L. 500 Scots, and only nine above L. 2000 of valuation, thus indicating that the landed property was much divided; and not a fourth of the whole was entailed, a smaller proportion than in most parts of Scotland. The estates of the Duke of Montrose, Lord Dundas, Sir Charles Edmondstone, and Mr Forbes of Callendar, the principal proprietors, were then rented at from L. 8000 to L. 14,000, and several others were worth from L.1000 to L.4000 a year; but the greater number were below L. 1000. Some of the proprietors have increased the value of their estates by means of embankments on the Frith of Forth. Several hundred acres, much of it worth a rent of L. 5 an acre, have thus been reclaimed and brought into cultivation, and a great deal more may be gained in the same manner. All the small proprietors, and most of the great ones, reside upon their estates; and several of the latter occupy considerable farms of their own, which they have improved, and continue to cultivate in a very judicious manner. There is, accordingly, a great number of seats over all the lower parts of the county. Before the Union between England and Scotland, considerable tracts were granted to the retainers and dependents, or the tenants of the principal proprietors and their heirs for ever; subject only to the payment of the rent of those times, which is now very trifling. These are called *feuars* or *portioners*, and, in some parishes, form a pretty numerous class. Their houses and fields still present a tolerably faithful picture of the rural economy of Scotland a century and a half ago.

Estates.

Woodlands.

There is a good deal of both natural and planted wood in Stirlingshire, and much of the former, in the state of coppice, has long yielded a regular income to the proprietors, little if at all inferior to the average rent of the arable land. Of oak coppice alone the extent is near 4000 English acres, of which more than two-thirds belong to the Duke of Montrose, growing near his seat of Buchanan, on the western extremity of the county. The Buchanan woods seem to be under very regular management, being divided into twenty-four *hags* or portions, of which one is cut every year. A few years ago, this produced from L. 16 to L. 24 the Scots acre, after leaving a number of *reserves* to stand for timber. Every acre gives at a medium about one ton and a half of bark, which, during the late war, sold at L. 18; and the small timber generally pays expences. Much of the land on which this wood grows is of little value for any other purpose; not worth half-a-crown an acre. On the same estate, and also in other parts of the county, extensive plantations have been made within the last fifty years.

Live Stock.

The mountainous parts of Stirlingshire are occupied with sheep of the black-faced or heath breed, and the lower hills by Highland cattle; and there the farms are necessarily of considerable extent. The arable land, however, is for the most part divided into small farms, especially the Carse lands on the Forth, where the general size does not exceed 50 or 60 acres. The rotation of crops, accordingly, as well as the

Crops.

Stirlingshire. general management, is seldom so good as on the Carse of Gowrie, a similar tract on the banks of the Tay in Perthshire, or in the border counties of Scotland. Yet very great crops of wheat and beans, and the other kinds of grain, are obtained from this naturally rich soil, which in many parts affords a rent of L. 4 and upwards the English acre. But besides a money rent, it is still not uncommon to exact poultry, carriages, &c. from the tenants; burdens which, though once general, are now almost unknown in those districts where an improved system has made the greatest progress. The land on the banks of the Forth is exceedingly well adapted for orchards, of which there are a few, but of no great extent. The island of Inchmurrin, in Lochlomond, the property of the Duke of Montrose, has been stocked with fallow deer for more than a century, the number about 240, which are properly attended to, and kept always in a thriving condition. Goats, about fifty years ago, were an important article in the western district near Lochlomond, much of the rent being then paid in kids and goat milk cheese; but they are now almost extinct.

Deer.

Manufactures.

The manufactures are carpets and other coarse woollens in the town of Stirling; paper, cottons, alum, copperas, soda, Prussian blue, &c. on an extensive scale near Campsie on the south-west quarter; spirits at several large distilleries, and iron goods at Carron. The *Carron Works*, celebrated all over Europe, were established upon the banks of the river of that name about sixty years ago, by Dr Roebuck and Messrs Caddel and Garbet, who were joined in the undertaking by several other gentlemen. By the charter of the company, they are authorized to employ a capital of L. 150,000, which is divided into 600 shares, and ten of these are required to give a vote in the management. During the late war they employed upwards of 2000 able bodied men, and paid in wages above L. 120,000 yearly. At these works all sorts of cast-iron goods are made, and also bar iron, said to be equal to the Russian; but particularly cannon and that kind called *Carronades*, which having been invented here, take their name from the works. The boring of the cannon is a very interesting operation, which is performed in about forty-eight hours by machinery moved by water. One of their engines raises upwards of 30 tons of water in a minute; and so extensive are the works, that they are said to consume every day about 200 tons of coals. They have water carriage from the Frith of Forth by means of the Carron, and to the Frith of Clyde by the Forth and Clyde Canal, which passes through the district, a little to the south of the Carron.

Carron Works.

Commerce.

Notwithstanding the favourable situation of Stirlingshire, on a navigable river, and between the east and west seas, which for thirty years have been connected by a Canal, it has but a small town population, and till lately, its commerce was inconsiderable. Even now half its exports, not including its agricultural produce, is supposed to be furnished by the Carron works. The principal town is Stirling, containing, in 1821, 7113 inhabitants; a place of great antiquity, which, though situated on the navigable part of the Forth, has little trade by water, and is chiefly indebted for its importance to its situation on the confines of the Highlands. Falkirk, on the eastern side of the county, a little to the south of the Forth and Clyde Canal, had a population in 1821 of 11,536, and is distinguished for its great fairs or *trysts* which are held in August, September, and October; where cattle, sheep, and horses, are brought for sale, to the value of almost half a million Sterling. Grangemouth, founded by Sir Lawrence Dundas, in 1777, on the angle formed by the junction of the Carron and the Forth and Clyde Canal, is now a considerable village, and the principal sea-port of the county: its trade is chiefly with the north of Europe, and along the east coast. It has a custom-house, a dry-dock, and other necessary works. The depth of water in the harbour is generally in spring-tides from 16 to 18 feet, and in neap-tides from 10 to 12. In 1810, the shipping of this port exceeded 60,000 tons. The only other town is Kilsyth, on the borders of Lanarkshire. On the east side there are a number of small villages, occupied partly by agricultural labourers and mechanics, and partly by weavers employed by the Glasgow manufacturers.

Stirlingshire.

Representation.

The county, which, in 1822, had 118 freeholders, sends one member to Parliament; and Stirling, its only royal burgh, is associated with Culross, Dunfermline, Inverkeithing, and Queensferry, in the elections for the Scottish burghs. A poor-rate is levied here only in a few parishes; the poor being chiefly supported, as in most parts of Scotland, by voluntary contributions.

Antiquities.

Stirlingshire exhibits remains highly interesting to the antiquary, and has been the scene of some of the most remarkable events in Scottish history. The Roman Wall, called the Wall of Antoninus, and vulgarly Græme's Dyke, which traversed this county, may still be traced in several places. The battle of Bannockburn, which secured the independence of Scotland, was fought on 24th June 1314, about three miles south from Stirling, where a stone is still shown in which the royal standard is said to have been fixed. The eastern side of the county was the scene of many other battles between the Scots and English; but these belong to the history of Scotland, and have been noticed under that head in the *Encyclopædia*. We may also refer on this point to Roy's *Military Antiquities* and Chalmers's *Caledonia*.

Population.

The population of Stirlingshire, according to the census of 1801, was 50,825; in 1811 it amounted to 58,174; and in 1821 to 65,376; of which 31,718 were males, and 33,658 females. The *families* employed in agriculture were 2600; in trade and manufactures 6641; in all other occupations 4492. The increase of population from 1811 to 1821 was 7202.

See the general works quoted under the former Scottish counties, and Dr Graham's *View of the Agriculture of Stirlingshire*. (A.)

STONE-MASONRY AND STONE-CUTTING.

Stone-Masonry.

Masonry Defined.

1. MASONRY is the art of building with stones: the art of reducing stones to regular or determinate forms is sometimes called *stone-cutting*, but is usually considered a branch of masonry. Workers in marble are also called masons; but it is stone-masonry only which we intend to treat of in this article; as marble masonry is rather a manual than a scientific art.

Early History.

2. The art of building with stone is undoubtedly of great antiquity; and its early history is difficult to trace beyond the existing remains of ancient buildings; the oldest of which are objects of wonder, chiefly on account of the difficulty of moving, with ordinary powers, the immense stones of which they are formed. There is one thing remarkable in these stupendous efforts of human labour; its directors have often been happy in the choice of almost imperishable materials, for a lasting evidence of their command of power. The remains of this kind of gigantic masonry are found in various parts of the earth; some of the finest specimens are the ancient Egyptian buildings; which seem to have been intended to resist the power of men, as well as the slow operations of time.

Greek Masonry.

3. The masonry of the ancient Greeks closely resembles that of the Egyptians: it is a more refined application of the same principles of construction, to a series of chaste and beautiful architectural forms, in which the ornamental part of the art has evidently been in that state of perfection, which is rarely, if ever surpassed. The roof of the Octagon Temple of the Winds may be considered the best example of their constructive skill, while it betrays their ignorance of the principles of the arch.

Roman Masonry.

4. In Roman masonry we find less of ponderous strength, and sound construction, than in the Egyptian and Greek, and rarely any thing approaching to the accurate and highly finished labours of the latter, but considerably more artificial and economical knowledge. If the manner of forming arches* and domes was not actually invented by the Romans, at least the merit of applying them successfully, in the art of building, was undoubtedly theirs; they also excelled in the composition of mortars and cements: hence, they found it easy to construct large works at a moderate expense, which could not have been accomplished by the limited methods of building of their predecessors. It gives us a high notion of the intrinsic value of the art of masonry, to examine its application by the Romans, whether it be in the celebrated Cloacæ, Aqueducts, Bridges, or the Military Roads of those enterprising people. To them also we owe the beautiful idea of covering a temple with a dome.

Early English Masonry.

5. After the decline of the Romans, the art of masonry, in Europe, gradually acquired its former importance through its application to the construction of castles, towers, and other places of defence; and eventually, it gained a complete ascendancy over the other building arts in the construction of Cathedrals, Monasteries, and the like. In our own island it made an equal if not a greater degree of progress than on the Continent. The science of masonry † appears to have attained the most perfect state it arrived at in those times, about the period when King's College Chapel, at Cambridge, was built (about 1512). From that time, or soon after, the knowledge of construction declined; but the researches of men of science have, in modern times, more than replaced those lost principles which, there can be little doubt, the elder free-masons possessed. Unfortunately, such principles are, even at the present time, as inaccessible to a plain workman as the mysteries of the master-mason were to the apprentice and fellow-craft of former ages; unless it be in some rare instances where the force of natural genius has risen superior to the difficulties before it, and a mere workman, like the "'prentice of Roslin Chapel," has outstripped the masters of technical science.

Principles of Gothic Masonry.

6. The most important principle of the free-masons, or, as they are usually called, the "Gothic builders," was that of reducing all the pressures of a vaulted roof to a few principal supports. These supports were either strong pillars, or buttresses, accordingly as the support was within the area, or formed a part of the external wall. The buttresses were made of considerable depth in the direction of the pressure, with a thin wall from buttress to buttress, for enclosing the building. If they had made the external walls of uniform thickness, according to the modern practice, a much greater quantity of material would have been required to balance the pressure of the vaulting. For similar reasons, the strength of their best vaulting consists in deep moulded ribs; the spaces between these ribs being formed of thin light stones, supported from rib to

* Perhaps the oldest arches, at present known, are those which Mr Belzoni discovered in Egypt; they are executed in bricks of the same size, and of the same material, as those the Egyptians used in the construction of their walls and pyramids. For farther remarks on the subject of Arches, see the Article BRIDGE, in this *Supplement;* and the Earl of Aberdeen's *Inquiry respecting Grecian Architecture,* page 191—211.

† What other term than *science* can be applied to that knowledge, which enables a mason to dispose large masses of stone-work over a considerable area, with only a few distant supports?

rib. The principles of construction of the Gothic builders may be readily shown by a model of wicker work, in the manner of Sir James Hall's truly elegant mode of explaining his ideas respecting the origin of Gothic vaulting. * The earliest notice we have seen, in architectural works, of any thing resembling the principles of construction just noticed, is given by Alberti, who, alluding to a method of building known to former architects, says, " The arches on which the roof was placed being drawn quite down to the foundation with wonderful art, known but to few ; so that the work upheld itself by being only set upon arches; for those arches having the solid earth for a chain, no wonder they stood firm without any other support." †

Masonry of the Sixteenth and Seventeenth Centuries.

7. Masonry, with some other arts, having been drawn out of their ordinary course by the peculiar state of society in the middle ages, fell back to their common level, if not below it, at the Reformation; the natural consequence of this change was the loss of the greater part of the knowledge which had been gained by the experience of several centuries. But even in the most depressed state of masonry, there were some individuals in whom the love of that excellence which animated their predecessors, was not subdued by want of encouragement; and some scattered works were executed which are worthy of notice, if our limited plan would allow of it.

Present State of British Masonry.

8. When Britain had become happily free from all internal disturbances, and there was little to occupy the time and attention of a rapidly increasing population, except the improvement of their own condition in life; the chief fruit of their exertions for this purpose was, an unprecedented extension of the foreign and domestic trade of the country; wharfs, docks, harbours, and lighthouses; canals, locks, roads, and bridges, became the necessary appendages of this new state of things; and, accordingly, it became desirable again to cultivate the art of masonry.

These important works also called forth a new profession, of which the celebrated Smeaton has been called the father. Smeaton's first work was the Eddystone Lighthouse, which, in originality of design, and soundness of construction, has not been equalled. Since its erection, such a succession of bold and useful works have been accomplished, that it would be difficult to enumerate them; ‡ it is sufficient to remark, that the masonry of our own age and country, as it is exhibited in these works, is without a parallel in preceding times.

State of Masonry on the Continent.

9. In the northern states of Europe, their best works are chiefly modelled after ours; and, with the exception of France, there is not in the southern states any considerable degree of encouragement given to any branch of masonry. It may nevertheless be remarked, that the principles of construction is a popular subject of study in Italy.

French Masonry.

10. In France, masonry has always been a popular art; partly, perhaps, from Paris being situate in the midst of a district which abounds in excellent building stone. The French government has always directed a considerable share of attention to the construction of roads, bridges, and military works; and, consequently, has afforded sufficient scope for its improvement. When, however, the larger works of the French masons are compared with those of our own countrymen, one very remarkable difference may be observed; the French works have more of the character of daring experiments, than that which ought to belong to the works of regular professors of an art; while the British works of the same kind have evidently been directed by men better versed in practical construction than in the refinements of science. There is, perhaps, more of novelty in the French works than is to be found in ours; but it may be remarked, that this novelty of character is often obtained by a sacrifice of fitness; as in the catenarian dome of the Pantheon, &c.; or of strength, as in the bridges of Nogent, Neuilly, &c. The true criterion of excellence in a useful art seems to be, fitness for producing the desired end in the best possible manner.

Sect. I.—Of Materials used in Masonry.

Materials.

11. The first object of attention, in a treatise on masonry, ought to be, the nature of the materials employed in it; because the greater part of the principles of an art always depend on the nature of the substances it is to be exercised upon.

Of Stones.

Nature of Stones.

12. Building stone is a dense, coherent body, of considerable hardness and durability, but generally brittle. It possesses these qualities in various degrees, according to the nature of its chemical elements, or the state of aggregation of its parts.

The structure of stones is either laminated or granulated, or of a mixed kind.

The chemical constituents of building stones are silica, alumina, lime, magnesia, and metals; combined with acids, water, and sometimes with alkalies; some other chemical elements are found in building stones, but not often in sufficient quantity to affect the nature of the stones.

Laminated Stones.

13. Laminated stones consist of thin plates, or layers, cohering more or less strongly together; when the layers are of considerable size, and cohere so slightly that they may be easily separated, the stones are said to be slaty. The layers are always nearly parallel to the quarry-beds of the stone, and they should always be horizontal, or as nearly so as

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* *Essay on the Origin, History, and Principles of Gothic Architecture*, London, 1813. Ware has collected most of the forms employed, in his *Tracts on Vaults*, &c. London, 1822.

† *Architecture* of Leon Baptista Alberti (Leoni's Translation), Book I. Chap. XII.

‡ See the Articles Bell-Rock Lighthouse, Bridge, Breakwater, Caledonian Canal, Docks, in this *Supplement*.

possible, in a building; otherwise the action of the weather will cause them to separate, and fall off in flakes. In sandstones, the direction of the layers may often be discovered by their different shades of colour; in others, by the position of minute scales of mica, which always lie parallel to the layers. In most stones the direction of the layers may be ascertained by the facility with which the stone yields to the tool in that direction; but a considerable degree of practice is necessary to acquire so nice a discrimination of resistance, and good workmen only attain it. Among laminated stones, those are the most durable in which the laminæ are least distinct, and the texture uniform. When the laminæ do not perfectly cohere, they are soon injured by frost, and they are wholly unfit for places alternately wet and dry.

Granular Stones.

14. Granular stones consist of distinct concretions resembling grains, either of the same, or of different simple minerals cohering together. When the structure is uniform, and the grains or concretions are small, stones of this kind are always strong and durable, if the concretions themselves be so. Granular stones are sometimes open and porous, but when they are uniformly so, they seldom suffer materially by frost; because their uniform porosity allows the expansive force of congealing water to be distributed in every direction.

Compound Stones.

15. Stones of a compound structure, partly laminated and partly granular, have more or less of the characters of the two classes before described; for it may be observed in coarse-grained granite that the laminated structure of some of its parts renders it very susceptible of disintegration.

All kinds of stone obtained from quarries are found divided by vertical or inclined seams, which are sometimes so close that they cannot be distinguished till the stones are wrought; but they often separate under the tool at such seams; and it is not safe to employ stone to resist any considerable transverse strain on account of the difficulty of knowing where those seams are.

Durability of Stones.

16. In the present state of our knowledge of this important subject, we may attribute the failure of building stones to two causes; the one chemical, and the other mechanical, which we shall here distinguish by the terms decomposition and disintegration.

Decomposition.

17. Decomposition consists in the chemical elements of a stone entering into new combinations with water, oxygen, or carbonic acid gas. Stones containing such elements as are readily acted upon by these external causes will be found most subject to decompose; and the process will be, in many kinds, much hastened by a loose texture.

Stones containing saline matter, as the felspar of some granites, are acted upon by water, particularly where the soluble salt is in considerable proportion; and in some stones the application of salt water soon destroys them. Dolomieu says, the houses at Malta are built with a fine-grained limestone, of a loose and porous texture, which speedily moulders away when it has been wetted with sea water. (Kirwan's *Geological Essays*, p. 148, 149.)

Stones containing iron, which is not in a maximum state of oxidation, are often destroyed by the absorption of oxygen and carbonic acid; the presence of moisture accelerates their decomposition, and it is always still further hastened by increase of temperature. According to the observations of Kirwan, stones containing iron in a low state of oxidation are of a black, a brown, or a bluish colour; and in some instances, when united with alumina and magnesia, they are of a gray, or a greenish gray; the former, as they become more oxygenized, change to purple, red, orange, and finally pale yellow; the latter become at first blue, then purple, red, &c. (Kirwan's *Geological Essays*, p. 145, 6.) But stones containing iron, combined with its maximum of oxygen, do not readily decompose, such are red porphyry, jaspers, &c. When stones contain manganese, lime, alumina, carbon, or bitumen, in particular states, they are subject to decomposition, from the affinities of one or other of these bodies; but nothing very decisive is, or perhaps can be, known respecting such changes, till some improvement be made in analytical chemistry, by which the state of combination of the constituents of minerals can be determined with more certainty.

Disintegration.

18. Disintegration is the separation of the parts of stones by mechanical action. The chief cause is the congelation of water in the minute pores and fissures of stones, which bursts them open, or separates small parts according as the structure is slaty or irregularly granulated. The south sides of buildings, in northern climates, are most subject to fail; because the surface is often thawed and filled with wet in the sunny part of the day, and frozen again at night. This repeated operation of freezing is also very injurious to sea walls, the piers of bridges, and other works exposed alternately to water and frost.* The decay and destruction of rocks being the effects of the same natural causes, the reader will find some further illustration of this subject in the Article MINERALOGY in this *Supplement*, Vol. V. p. 477.

Resistance to Wear.

19. The resistance of stones to wear and tear is, for many purposes, a subject which it would be useful to investigate, since on this resistance depends also the labour of working them. From some experiments made by Rondelet, it appears that granite will bear eight times as much wear as veined white marble; and that the labour of sawing granite was about ten times greater than that of sawing veined white marble. (*Traité de l'Art de Bâtir*, Tome I. p. 95.)

Scotland abounds in quarries of excellent building sandstone; such, in particular, are the quarries at Culello, in Fifeshire, which furnished the stones for the monument erected at Yarmouth to the memory of Lord Nelson, and that at Edinburgh to the memory of Lord Melville. Nothing can exceed the beauty of the sandstone used in those noble

* The decayed state of the piers of Westminster and Blackfriars' Bridges shows us how very little this important subject has been studied; as well as the necessity of studying it.

structures; and besides beauty, and other valuable qualities, it has in a high degree that of being easily chiselled into the smoothest and finest forms.

Of Mortars and Cements.

Mortars and Cements.

20. In the greater part of works executed in stone, it is necessary to use some kind of cementitious matter for connecting the parts together, to render them firm and compact. Works to be exposed to the action of water, immediately after being built, require this cementitious matter to be of such a nature, that it will indurate under water. Hence it is, that we have occasion for two species of mortar; one which will set and harden under water, called a *water mortar*, or cement; and *common mortar*.

Nature of Common Mortar.

21. If a piece of limestone, or chalk, be slowly calcined, so as to expel the whole, or nearly the whole, of its carbonic acid, it loses about 44 *per cent.* of its weight; and on a small quantity of water being added, it swells, gives out heat, and falls into a finely divided powder, called slacked lime. The bulk of the powder is about double that of the limestone. If this powder be rapidly formed into a stiff paste with water, it sets or solidifies as a hydrate of lime, and ultimately hardens by the absorption of carbonic acid from the air. This constitutes common building mortar. Hydrate of lime consists of lime, 100 parts, and water 31 parts.

Water Mortar.

22. If any substance, in powder, which contains much iron in a low state of oxidation, be mixed with slacked lime, the mixture will become harder and more coherent than when lime alone is employed; and it possesses the valuable property of acquiring an equal, or perhaps greater degree of hardness, if it be immersed in water as soon as it is formed into a paste. This constitutes water mortar. A paste of hydrate of lime alone softens and dissolves in water.

Alumina, silica, and manganese, are endowed with the same property as oxide of iron, but in an inferior degree.

It may be observed, in forming such combinations, that when the lime is in excess, it separates; and in favourable situations, either crystallizes or forms stalactites; indicating that there is a definite proportion according to which the materials should be combined to form the best cement.

Use of Sand in Mortar.

23. If some kind of matter, in the state of particles or grains, be mixed with the cementing material, and then the mixture be formed into a paste with water, the strength and hardness of the cement will greatly depend on the nature of the particles added to it. In order that the cement may be improved by such addition, it is necessary that the hardness of the particles should at least be equal to the greatest degree of hardness the cement can acquire; and also, that the affinity between these particles and the cementing matter should exceed the affinity between the parts of the cement itself.

From this explanation it will readily appear, that any substance which is added to a cement for the purpose of increasing its bulk, its hardness, or its strength, ought to be in particles or grains; and that no soft, earthy, or pulverent matter is fit for this purpose.

It will be equally apparent, to those who have considered the nature of chemical combination, that the cementing part of the materials employed in the composition of mortars and cements, should be in the finest state of division that it is possible to reduce them to.

An attentive consideration of these principles will afford an easy solution of some of the most interesting questions to which this important subject gives rise; and correct some errors that have originated from a partial examination of the phenomena. We have now to examine the qualities of those materials which naturally occur in the earth; from these must be selected the kinds that can be obtained at the least expense for the place they are to be employed at, when their quality is suitable for the nature of the work.

Limestones.

24. The cementing materials are chiefly from the different species of limestone, to which may be added puzzolana, terras, iron ores, basalt, and other substances of a like character. The limestones may be divided, as regards cements and mortars, into three classes; common limestone, poor limestones (*chaux maigre* of the French), and cement stones.

Common Limestones.

25. Common limestones consist of carbonate of lime with very little of any other substance; they produce a white lime, which slacks freely when well burnt; they dissolve in diluted muriatic acid with only a small portion of residue, and never contain more than a trace of iron. They differ much in external characters, as chalk, marble, common compact limestone, &c.

These limestones do not form water cements without the addition of other kinds of cementing matter; hence they are usually employed for common mortar. The hardest marble and the softest chalk make equally good lime when well burnt; but chalk lime will slack when not perfectly burnt, and, therefore, seldom has a sufficient quantity of fire; whereas stone lime must have sufficient to make it slack. It has also been observed, that stone lime does not reabsorb carbonic acid so rapidly as chalk lime. (Higgins *on Mortar and Cements*, p. 29.)

Lime, made from common limestones, sustains very little injury from being kept after it has been formed into a thin paste with water, provided the air be effectually excluded; indeed, Alberti mentions an instance of some which had been covered up in a ditch for a very long time, that was of an excellent quality.

Poor Limestones.

26. Poor limestones consist of carbonate of lime united with silica, alumina, and metallic oxides. They in general produce a buff-coloured lime, but sometimes it is white. When the lime is white, there are no metallic oxides present. They contain a considerable portion of matter, which is insoluble in acids. They differ considerably in external characters; the blue lias, the Sussex clunch, and Sutton limestones, may be cited as instances.

The lime of poor limestones does not slack freely; and it would always be desirable to reduce it to powder by grinding, in preference to slacking, because in slacking a part of its setting property is destroyed. When poor lime is slacked, it should be made into mortar, and used immediately. Moisture does such lime more injury than the reabsorption of

carbonic acid. And mortar made of it ought not to be disturbed after it has begun to set or harden.

Poor limestones are subject to vitrify in burning, unless the heat be increased gradually; but by a little management in this respect they will bear a heat sufficiently intense to convert them into good lime.

The lime of poor limestones makes excellent common mortar, when the precautions we have pointed out have been attended to. It is much superior to mortar made from common limestones. It is not, however, sufficiently powerful for a water cement without the addition of Puzzolana, Terras, or other like substances.

Cement Stones.

27. Cement stones. We have taken the liberty of giving this name to the class of earthy bodies which afford a good water-cement without addition; and it appears to be essential for that purpose that there should be at least 50 *per cent.* of carbonate of lime in the stone. Those cements which answer best are made from stones containing about 60 *per cent.* The other substances usually contained in these stones are, silica, alumina, oxide of iron, sometimes oxide of manganese, carbonate of magnesia, with traces of other alkaline and earthy salts. Cement stones are in great part soluble, with effervescence, in diluted muriatic acid; they lose about one-third of their weight by calcination, after which they do not slack, but may be ground into a fine powder, of a brown colour, of different degrees of intensity according to the nature of the stone. Those now used to make cement are found in rolled pieces, or in nodules, with septa of carbonate of lime, on the sea-coast at Sheppy, Harwich, and near Whitby, and at Boulogne on the French coast. The nodules are plentifully dispersed through the London clay stratum, and the alum shale of Whitby; they are termed clay-balls, ludus helmontii, septaria, &c.

Cement stones are also liable to vitrify in burning, either from being quickly exposed to a strong heat, or by making the heat too intense.

When cement stones have been calcined and ground, the powder thus obtained should be kept in a very dry place, as its setting property is soon destroyed by moisture. It absorbs moisture rapidly from the air; and, therefore, it should be as little exposed as possible; but when closely packed, and in a dry place, it may be kept a considerable time.

Artificial Cement.

28. There are perhaps few mineral bodies which would answer as well as clay-balls for making cement; unless it be calcareous marls; but there are very few situations where the means of forming an artificial cement are wanting; the manner of proceeding must depend on the nature of the substances employed. In general it will be necessary to mix slacked lime with the substance containing silica, alumina, and oxide of iron, and calcine them together, and afterwards grind them. The iron should be in the state of protoxide, to the amount of from 13 to 18 *per cent.* by weight. The quantity of lime may be about 30 *per cent.* or 53 *per cent.* of carbonate of lime; the silica and alumina being in equal portions: hence, in the raw materials, one hundred parts by weight may consist of

Carbonate of lime....	53
Protoxide of iron...........	18
Silica and alumina..........	29
	100

29. There are several mineral bodies which, combined with lime, form good cements; some of these may be used in their natural state, others require calcination. Puzzolana and tarras are of the former kind; basalt, iron ores, and ferruginous clay, belong to the latter class.

Puzzolana.

Puzzolana is a volcanic production much used in making water cements. It was known to the Romans, and employed by them both in ordinary buildings and water works. Its colour is reddish or reddish brown; and gray or grayish black; that of Naples is generally gray, that of Civita Vecchia more generally reddish brown.

Its surface is rough and uneven, and it has a baked appearance; when broken and examined by a magnifying glass it appears to be a spongy substance, with innumerable small cavities like a cinder, and not much harder. It comes to this country in pieces varying in size from the bulk of a nut to that of an egg. It is very brittle, and has an earthy smell. Specific gravity from 2·570 to 2·785. It does not effervesce with acids; and is not diffusible in cold water.

The iron it contains is not oxidated; and, being finely divided and dispersed through its mass, offers a large surface which quickly decomposes the water with which it is mixed when made into mortar. The union of the oxygen of the water with the iron is the principal cause of the solidification of water mortar; and this union is greatly facilitated by the heat given out by quicklime.

Tarras.

30. The substance called Tarras or Trass, found near Andernach, on the Rhine, is endowed with similar properties. Its colour is light gray or brownish gray. Its surface is rough and porous; and it is often found mixed with other matter. It is sometimes so hard that it yields with difficulty to the knife. According to Bergman, it contains more lime than puzzolana does, and effervesces slightly with acids.

Smeaton found puzzolana to be equal, if not superior, to tarras in forming a water cement with Aberthaw lime; he also observed that tarras is inferior for work which is to be alternately wet and dry.

31. If any stone be employed in which the iron is perfectly oxidized, it will be necessary to abstract some portion of the oxygen from the iron in the process of calcination, on the same principle as the reduction of iron from the ore is effected. (See IRON-MAKING in this *Supplement.*) It is also necessary to employ similar means to restore the cementing power of materials that have attracted moisture after being calcined.

SECT. II.—OF THE PRINCIPLES OF STRENGTH AND STABILITY IN MASONRY.

Resistance of Stones.

32. The strength and stability of stone-work depends partly on its mass or weight, and partly on the

resistance of the materials. And, since we cannot imagine incompressible fulcra, nor that the materials of masonry are infinitely hard and inflexible, as writers on elementary mechanics consider them to be; therefore, it is essential that the resistance of materials should be considered, and the effect of their weight allowed for in estimating the power of the straining force.

The resistance of stones being dependent on their state of aggregation, and not on the hardness or density of their elementary parts, their comparative strength cannot be judged of by these qualities; indeed, there are few kinds of materials of which the resistance is so uncertain as that of stone; hence, it is not at all adapted for any support where its resistance depends on its cohesion only, unless it be very carefully examined, and abundant strength be allowed. (See § 15.) The resistance of stone to compression is less affected by its irregular nature, particularly as it is usually employed in blocks of inconsiderable height; and, in general, there is scarcely any reason to be sparing of a material which it is often more expensive to reduce than to employ in large blocks. When, however, works of great magnitude are to be constructed, the weight of the materials themselves forms the chief part of the straining force; and, consequently, in such cases it becomes desirable to form a tolerably accurate estimate of their power.

33. This power is limited by a property of bodies, which has not received that degree of attention its importance would lead us to expect: we shall in this place make it the basis of an investigation of the power of materials to resist a force applied in any given direction; and show its application to some of the cases where a mason is most likely to need the assistance of calculation.

When a material is strained beyond a certain extent, every time the strain is increased to the same degree, there is a permanent derangement of the structure of the material produced; and a frequent repetition will increase the derangement till the parts actually separate. (See CARPENTRY in this *Supplement*, p. 622, 623.) When a small base rests upon a considerable mass of matter, as a pier on the ground, the quantity of derangement will increase only till the mass be compressed to that degree which renders the increase insensible; but in many cases a number of years will elapse before the settlement becomes insensible.

34. The strain which produces permanent derangement in the structure of a material varies from one-fourth to two-fifths of that which would destroy its direct cohesion. In stone the lower value should be taken, on account of its being subject to so many defects; and, for the present, let this strain be denoted by f lbs. upon a superficial foot.

35. Imagine ABCD to be a block, Plate CXVIII. fig. 1, strained either in the direction EF or FE, by a force W; and let BDF be a line drawn in the same plane as the direction of the straining force; and perpendicular to the axis ab of the block. Now, if we consider the resistance of the block to be collected at the centres of resistance t and c; then, tF will represent a lever acted upon by three forces; that is, the resistances at t and c, and the straining force at F. If the angle, FEg, be denoted by a; then, the effect of the force W, reduced to a direction perpendicular to the lever, will be expressed by cos. a W. (1.)

Also, if T be the resistance at t, and C the resistance at c, we shall, in the case of equilibrium, have

$$C - T = \cos. a\, W. \qquad (2.)$$

And, by the property of the lever,

$$\frac{\overline{tc} \times T}{\overline{cF}} = W \cos. a \qquad (3.)$$

$$\text{Hence, } \frac{\overline{tc}}{\overline{cF}} = \frac{C}{T} - 1 \qquad (4.)$$

36. Without stopping to notice some maxims furnished by this equation (see the Art. BRIDGE, *Prop. B*), we will proceed to explain the notation used in the investigation which follows:

$l =$ the length AB.
$d =$ the depth BD, measured in the same plane as the direction of the strain.
$b =$ the breadth.
$z =$ the distance of the neutral point e from the axis ab.
$y =$ the distance of the point g from the axis ab.
$p(\frac{1}{2}d - z)$, and $p(\frac{1}{2}d + z)$ the respective distances of the centres of resistance t and c from the neutral point; and, consequently,
$pd =$ the distance, ct, between them. And,
$g(\frac{1}{2}d - z)$, and $g(\frac{1}{2}d + z)$ the respective distances of the centres of gravity of the sections into which the neutral axis divides the block, counted from the neutral point.

The leverage, cF, expressed in this notation will be $\frac{l \sin. a}{\cos. a} + y - \frac{1}{2}pd + (1-p)z$; consequently, equation (4) becomes

$$\frac{pd}{\frac{l \sin. a}{\cos. a} + y - \frac{1}{2}pd + (1-p)z} = \frac{C}{T} - 1 \qquad (5.)$$

37. Now, it is shown, by writers on the resistance of solids, that the resistance of any section, collected at its centre of pressure, is equal to its cohesive force multiplied by the distance of its centre of gravity from the neutral axis, and divided by the distance of the point of greatest strain from the neutral axis. (Emerson's *Mechanics*, Prop. 77. 4to. ed.)

$$\text{Accordingly we have } C = \frac{fbg(\frac{1}{2}d+z)^2}{\frac{1}{2}d+z} \qquad (6.)$$

$$\text{And} \qquad T = \frac{fbg(\frac{1}{2}d-z)^2}{\frac{1}{2}d+z} \qquad (7.)$$

Therefore $\frac{C}{T} = \frac{(\frac{1}{2}d+z)^2}{(\frac{1}{2}d-z)^2}$; which being substituted in Equation (5), we obtain

$$(3p-2)z^2 - 2z\left(\frac{\sin. a . l}{\cos. a} + y\right) + \tfrac{1}{4}pd^2 = o \qquad (8.)$$

If the block be rectangular $p = \frac{2}{3}$, and, therefore,

the distance of the neutral point from the axis is

$$z=\frac{d^2}{12\left(\frac{l\ \sin.\ a}{\cos.\ a}+y\right)} \qquad (9.)$$

38. The value of z for a rectangular section being determined, the magnitude of the straining force is easily found, so that it may not exceed the power of the material; for, by the properties of the lever,

$W\cos.\ a=\frac{pdC}{\frac{l\ \sin.\ a}{\cos.\ a}+y+\frac{1}{2}pd+z(1-p)}$; and since C $=fbg(\frac{1}{2}d+z)$ by Equation (6), and

$z=\frac{d^2}{12\left(\frac{l\ \sin.\ a}{\cos.\ a}+y\right)}$ by Equation (9), and $g=\frac{1}{2}$ by the form of the section, we have

$$W=\frac{fbd^2}{d\cos.\ a+6l\sin.\ a+6y\cos.\ a} \qquad (10.)$$

39. In particular cases this formula becomes more simple,—for example, when the distance of the point g from the axis ab is o, that is, when $y=o$,

$$W=\frac{fbd^2}{d\cos.\ a+6l\sin.\ a} \qquad (11.)$$

In a column, or pillar, the section of greatest strain will be at the middle of the length, as at BD in fig. 2; and the direction EF of the straining force is usually parallel to the axis; and then sin. $a=o$, and cos. $a=1$, and therefore $W=\frac{fbd^2}{d+6y}$ (12.)

When the direction of the straining force coincides with the axis, or when $y=o$, the strain on a column or pillar is expressed by the equation

$$W=fbd \qquad (13.)$$

These equations apply also to tensile forces.

When the strain becomes transverse, or when EF is perpendicular to the axis, as in fig. 3, then cos. $a=o$, and sin. $a=1$, hence $W=\frac{fbd^2}{6l}$ (14.)

If the block be supported at the ends, and the load be applied in the middle of the length, as in fig. 4, the fracture will take place at BD; and W in equation (14) will be the pressure on either support, which is obviously half the load in the middle.

40. In any of these equations it is immaterial how the load be distributed, provided that the line of direction be that which passes through the centre of gravity of the mass supported, and the weight be the whole weight of that mass. Or, if the strain be the combined effect of several pressures, then the direction must be that of the resultant of these pressures, as determined by the principles of mechanics. (See Carpentry, p. 627, in this *Supplement*.

41. If a slab of equable thickness and width be supported along two of its sides, as at AC, AB in fig. 5, and it be strained by a force acting at D, in a direction perpendicular to its surface, and DE be made equal to DB, then the fracture will take place in the direction EB; for it may be shown, by the principles of the maxima and minima of quantities, that the resistance, according to that line, is a minimum. And since, in that case, EB=2 FD, we shall have, by equation (14), $W=\frac{fd^2}{3}$ (15.)

A force uniformly diffused over the surface of the slab would fracture it in the direction CB, shown by a dotted line in the figure, and if w be the load in pounds upon a square foot of the surface, then the proper values being substituted for the leverage and breadth in equation (14), $w=\frac{fd^2(\overline{CD}^2+\overline{DB}^2)}{\overline{CD}^2\times\overline{DB}^2}$ (16.)

The strength of a series of steps bearing upon one another, as in the perspective sketch, fig. 6, may be determined with sufficient accuracy by the last equation, supposing the depth to be the mean vertical depth of any one step; as, for example, taken at GH in fig. 7, the figure showing the ends of the steps.

42. The case to which equation (14) applies, affords the most convenient, as well as the most accurate, means of determining the value of f for any material; and, supposing it to be one-fourth of the absolute cohesion (§ 34), the last column of the following table of experiments gives its value for various stones, mortars, &c. in the nearest simple numbers under the calculated value.

Table I.—*Experiments on the Transverse Strength of Stones, &c. to the Case Equation* (14.)

No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Length l	Depth d	Breadth b	Breaking Weight.	Values of $f=\frac{1}{4}$ of the absolute strength of a Square Foot.
1	Statuary marble . .	169·12lbs.	15 inches	1·075 in.	1·075 in.	25 lbs.	65,000 lbs.
2	Ditto . .		7·5	1·08	1·05	55	73,000
3	Ditto . .		7	1·075	1·075	65	78,000
4	Dundee stone .	163·80	7	1·5	1·45	207	95,000
5	Portland stone . .	132	21	1·5	2	28	28,000
6	Ditto . . .		12	1·45	2	50	30,000
7	Ditto . . .		6	1·55	2·07	135	35,000
8	Ditto . .		15	1·25	1·2	30	26,000
9	Craigleith white sandstone	147·6	7	1·55	1·55	68·5	26,000
10	White sandstone from Hailes Quarry . .	134·8	7	1·5	1·55	61·5	26,000

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No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Length l	Depth d	Breadth b	Breaking Weight.	Value of $f=\frac{1}{4}$ of the absolute strength of a Square Foot.
11	White sandstone from Longannet	138·25	9	1·525	1·45	46	26,000
12	Ditto . . .		4.5	1·45	1·525	80	23,000
13	Ditto . . .		3·5	1·55	1·55	116·5	24,000
14	Bath stone . .	123·4	2.75	1	1	29	17,000
15	Red porphyry . . .		2·5	0·4	1	60	101,000
16	Welsh roof slate . .		6	0·25	$1\frac{1}{2}$	30	414,000
17	Scotch roof slate . .		6	0·25	$1\frac{1}{2}$	25	345,000
18	Common brick, new .		4	2·5	4	201.5	6,900
19	Ditto old .		4	2·5	4	171·5	5,900
20	Best stock brick .		4	2·5	4	222	7,600
21	Mortar from an old castle in Sussex		3	1	1	18·5	12,000
22	Mortar, common .		0·75	0·35	$1\frac{5}{8}$	11·5	9,300
23	Mortar in the joints of two inch cubes of stone, one month after being joined . .		8 pou.	2 pou.	2 pou.	6·75liv.	1,400

Numbers 18, 19, and 20, are from Barlow's *Essay on the Strength of Timber*, &c. p. 250; each a mean of three trials.

Number 23, from Rondelet's *Traité de l'Art de Bâtir*, Tome III. p. 377, lowest result; the rest of the experiments were made by the writer of this article.

We have not availed ourselves of the experiments of Gauthey (Rozier's *Journal de Physique*, Tome IV.) on the transverse strength of stones; because those he fixed at one end appear to have been injured in fixing, and only a calculated result is given for the other specimens supported at both ends; both of which are given in the Article Strength of Materials in the *Encyclopædia*.

43. Several experiments have also been made, with the intention of measuring the direct resistance to extension or compression; but theory indicates so nice an adjustment of the direction of the straining force to be necessary in these experiments, that the reader may expect the results to differ as widely among themselves as they do from theoretical calculation.

Table II.—*Experiments on the Direct Resistance of Stones, &c. to the Case Equation* (13.)

No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Area of Specimen.	Weight that pulled it asunder.	Value of $f=\frac{1}{4}$ of the absolute strength of a Square Foot.
1	Hard stone of Givry . .	147 lbs.	96 lines	164 livres	8,400 lbs.
2	Tender stone of Givry . . .	130	324	183	1,400
3	Mortar of sand and lime 16 years old .		1 pouce	53	1,800
4	Plaster of Paris . , . .		1	76	2,500
5	Adhesion of mortar to lias stone, joined 6 months		4	64	547
6	Adhesion of mortar to brick, joined 6 months		4	138	1,180
7	Adhesion of mortar to tile, joined 6 months		4	141	1,200

The experiments, Nos. 3, 4, 5, 6, and 7, are extracted from Rondelet's *L'Art de Bâtir*, Tome I. p. 312.

Nos. 1 and 2, by Gauthey, Rozier's *Journal de Physique*, Tome IV. p. 414. In the Article Strength of Materials, in the *Encyclopædia*, these experiments have been quoted as experiments on compression, by mistake.

44. In the resistance to actual fracture, from a compressive force, the joint effect of cohesion and friction is concerned, and, therefore, a much greater force is required to crush than to tear asunder the same quantity of material. The resistance to fracture might be investigated on principles analogous to those we intend to employ in determining the pressure of earth against retaining walls, &c. (See also Carpentry, p. 623, in this *Supplement*.) But we conceive, that it is neither prudent, useful, nor necessary, to load the parts of a structure beyond that limit we have made the basis of our investigation. (See § 34.) Rondelet has observed, that the load under which a stone began to split was, nearly always, two-thirds of that which crushed it; but that stone, of some kinds, began to split with half the load that crushed it (*L'Art de Bâtir*, III. 86 et 101): the value of f should, therefore, not exceed one-fourth of the force which splits stone, and supposing the splitting force to be always half the crushing one, we shall have f=one-eighth of the crushing force.

45. In this, as in the preceding tables, the reader will observe, that the results of all experiments are given in the original weights and measures; but that the value of f and the weight of a cubic foot are in English pounds Avoirdupois, and for an English foot. The foreign weights and measures are distinguished by their foreign names.

TABLE III.—*Experiments on the Resistance to Crushing.*

No. of Expts.	Substance tried.	Weight of a Cubic Foot.	Area of Specimen.	Weight that Crushed it.	Value of $f=\frac{1}{8}$ of the Crushing Force for a Square Foot.
1	Porphyry	179·44 lbs.	20 lines	5,208 livres	640,000 lbs.
2	———	174·9	4 pouces	119,808	500,000
3	Granite, Aberdeen blue . .	164·06	2·25 inch.	24,556 lbs.	196,000
4	——— Peterhead, hard and close grained .		2·25	18,636	149,000
5	——— Cornish . . .	166·37	2·25	14,302	114,000
6	——— gray	171·06	4 pouces	39,168 livres	165,000
7	——— rose Oriental . .	166·32	4	52,704	220,000
8	Marble, white statuary . . .	172·5	2·25 inch.	13,632 lbs.	109,000
9	——— ——— ——— . .		1	3,216	57,000
10	——— ——— ——— . .	168·37	4 pouces	19,584 livres	83,000
11	——— veined white, Italian . .	170·37	2·25 inch.	21,783 lbs.	174,000
12	——— variegated red, Devonshire . .		2·25	16,172	129,000
13	Dundee stone . . .	158·12	2·25	14,918	119,000
14	Craigleith stone, with the strata .	153·25	2·25	15,550	124,000
15	Do.		2·25	12,346	98,000
16	Bromley Fall sandstone near Leeds, with the strata	156·62	2·25	13,632	109,000
17	Portland stone . . .	151·43	2·25	10,284	82,000
18	Do.		4	14,918	67,000
19	Culello white sandstone . .	151·43	2·25	10,264	82,000
20	Yorkshire paving stone . .	156·68	2·25	12,856	102,000
21	Hard stone of Givry . . .	147·31	324 lines	11,208 livres	85,000
22	Tender stone of Givry . . .	129·43	576	5,880	25,000
23	Saillancourt stone, of which the arches of the bridge of Neuilly are constructed .	141·31	4 pouces	7,280	30,000
24	Fourneaux stone, used for the pillars of All Saints, at Angers . .	160·68	4	26,600	110,000
25	Bagneux stone, used for the lower part of the pillars of the Pantheon at Paris .	137·12	25centim.	6,125 kilog.	62,000
26	Stone used for the bridge of St Maxence .	156·25	4 pouces	23,380 livres	97,000
27	Caserte stone, in Italy . .	169·87	4	36,142	150,000
28	Stone of which the temples at Pæstum are built	140·87	4	13,720	58,000
29	Travertino, of which the chief of the ancient buildings at Rome are built .	147·37	4	18,112	77,000
30	Derbyshire grit, a friable red sandstone .	144·75	2·25 inch.	7,070 lbs.	56,000
31	Ditto, from another quarry . .	151·75	2·25	9,776	78,000
32	Roe stone, Gloucestershire . .		2.25	1,449	11,500
33	Tufa, from Rome . .	76·00	4 pouces	3,520 livres	15,000
34	Chalk		2·25 inch.	1,127 lbs.	9,000
35	Pumice-stone . . .	37·81	4 pouces	2,100 livres	8,900
36	Brick, hard and well burnt . .	97·31	378 lines	5,280	34,000
37	—— pale red	130·31	2·25 inch.	1,265 lbs.	10,100
38	—— red, mean of two trials . .	135·5	2·25	1,817	14,500
39	—— Stourbridge fire		2·25	3,864	30,900
40	Mortar of lime and sand well beat together, 18 months old	118·31	4 pouces	2,552 livres	10,900
41	Do. 16 years old . . .		4	2,864	12,000
42	Do. not beaten, 18 months old . .	101·56	4	1,866	7,900
43	Do. of lime and pit sand, 18 months old .	99·25	4	2,475	10,600
44	Do. beaten together, 18 months old .	118·93	4	3,420	14,600
45	Do. of lime and pounded tiles, 18 months old	91·06	4	2,896	12,300
46	Do. beaten together, 18 months old .	103·93	4	3,970	16.900
47	Do. do. 16 years old . .		4	4,948	21,000
48	Do. from an ancient wall at Rome . .	89·37	4	4,248	18,000
49	Do. from the Pont du Gard . .	93·75	4	3,090	13,000
50	Lastrico, brought from Naples . .	62·5	4	4,664	19,400

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The Experiments, Nos. 1, 21, 22, and 36, were made by Gauthey. (Roz. *Journal de Physique*, Tome IV. p. 406.) Those numbered 3, 4, 5, 8, 9, 11, to 20, 30, 31, 32, 34, 37, 38, and 39, were made by Mr George Rennie. (*Philosophical Transactions for* 1818.) The others were made by Rondelet. (*Traité de l'Art de Bâtir*, Tome I. and Tome III.) We have selected those which will be most useful, with others of a more interesting and curious nature; such are Rondelet's experiments on the effect of beating mortar, the strength and density of ancient mortar, and the resistance of stones used in ancient and modern structures.

46. It was observed by Rondelet, in the course of his very numerous experiments, that it was not the heaviest stones which offered the greatest degree of resistance to compression, but those of a fine even grain and close texture, with a deep colour; that of granites, the most compact and perfectly crystallized are the strongest (*L'Art de Bâtir*, I. 213, 215); and when all other qualities were the same, it appears that the strength was in proportion to some function of the specific gravity.

The writers who have contributed to our experimental knowledge of the strength of stones are not numerous; the chief are Emerson, in his *Mechanics*, 4to Ed. p. 115; Gauthey, in his *Memoire sur la charge que peuvent porter les Pierres* in Rozier's *Journal de Physique*, Tome IV. 1774, and in his *Construction des Ponts*, Tome I. p. 267; Coulomb, *Mémoires présentés à l'Acadèmie*, 1773; Rondelet, in his *Traité de l'Art de Bâtir*, Tome I. et III. The latter volume contains the experiments made by Perronet and Soufflot. Rennie, *Philosophical Transactions* for 1818, or *Philosophical Magazine*, Vol. LIII.; Tredgold, *Philosophical Magazine*, Vol. LVI. p. 290.

Actual Load put on Stone in Practice.

47. The last column in each of the three tables of experiments shows the greatest load that we suppose should be borne by a superficial foot of the different kinds of stone contained in those tables; we now propose to give the results of some calculations respecting the extent to which stone has been loaded in practice. The foreign ones are reduced to our own weights and measures, and the whole stated in round numbers.

The pillars of the Gothic church of Allsaints at Angers, of the stone, No. 24, Table III. support on each superficial foot a pressure of 86,000 lbs.*

The pillars of the dome of the Pantheon at Paris, the lower part of which are of Bagneux stone (No. 25, Table III.), support on each superficial foot 60,000 lbs.†

The pillar in the centre of the Chapter-house at Elgin, which is of red sandstone, supports on each superficial foot 40,000 lbs. ‡

The piers which support the dome of St Paul's, in London, sustain a pressure on each superficial foot of 39,000 lbs. †

The piers which support the dome of St Peter's at Rome, sustain a pressure on each superficial foot of 33,000 lbs. †

The pressure on the key-stone (No. 23, Table III.) of the Bridge of Neuilly has been estimated for each superficial foot at 18,000 lbs.§

On these examples we have to remark, that the calculators of them have considered the pressures to be uniformly distributed over the pressed surface; this can only be true when the direction of the resultant of the straining force coincides with the axis of the pier or pillar; besides, stones cannot be wrought absolutely level, nor bedded in perfect contact. From these circumstances, the strength of piers, columns, pillars, and arch-stones, should be estimated by equation (12), and when the line of direction falls within the pier, always making $y =$ half the least dimension of the section, an allowance which will include the effect of the greatest possible inequality of action.

We shall, in that case, have $\dfrac{fbd^2}{d+\dfrac{6d}{2}} = \dfrac{fbd}{4} = \text{W}.$ (17.)

If the pressure on the Bagneux stone in the piers of the dome of the Pantheon at Paris be estimated by this formula, it will be found that it is sufficient to split the stones, and this has actually happened.‖

Principles of Arches, Domes, &c.

48. The chief elements of the theory of arches have already been given in the Article Bridge (Sect. II.) in this *Supplement*, to which we refer the reader, at the same time expressing a hope that the excellent article referred to will be useful in correcting some absurd notions respecting catenarian and other curves, which are too commonly entertained. The conical support of the lantern of St Paul's is a fine example of an appropriate form, while the catenarian dome of the French Pantheon exemplifies a scientific blunder of the first magnitude.¶

The principles of domes, of groins, and of vaulting of every kind, are the same as those of arches, excepting that each kind has its peculiar manner of distributing the load on the different parts. See Prop. M and N, Art. Bridge.

Of the Pressure of Earth, Fluids, &c. against Walls.

Pressure of Earth against Walls.

49. When a high bank of earth, or a fluid, is to be sustained by a wall, as it is often necessary to do in forming bridges, locks, quays, reservoirs, docks, and

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* Gauthey, Rozier's *Journal de Physique*, Tom. IV. p. 409, or *Construction des Ponts*, Tom. I. p. 273.

† Rondelet, *L'Art de Bâtir*, Tom. III. p. 74.

‡ Telford, *Edinburgh Encyclopædia*, Art. Bridge, p. 505.

§ Gauthey, *Construction des Ponts*, Tom. I. p. 260.

‖ Gauthey, *Construction des Ponts*, Tome I. p. 273.

¶ La charge considérable que cette voûte devait porter à son sommet, a déterminé à choisir pour la courbe de son ceintre *la chainette*. *Traité l'Art de Bâtir*, II. 308.

military works, the construction is very expensive, however economical the means employed may be; hence it is desirable to devote some space to an object of which the importance is manifest.

Let EC, Plate CXVIII. fig. 8, be the line according to which the earth would separate, if the wall were to yield in a small degree; then AEC will represent the section of the prism of earth, the pressure of which causes the wall to yield.

Put W=the weight of the prism AEC, when its length is unity.

R=the resistance of the wall, when its length is unity.

a =the angle ECa, which the plane of fracture makes with a vertical line.

c = the angle ACa, which the back of the wall makes with a vertical line.

F=the friction of the earth when the pressure is unity.

h = the vertical height of the wall aC in feet.

and S=the weight of a cubic foot of earth, water, or other matter to be supported.

If g be the centre of gravity of the prism of earth, the triangles rpg, CaE, being similar, the effort of the prism to slide, in the direction EC, reduced for the friction, will be $=\dfrac{W(1-F\tan.a)}{\sec.a}$ (18.)

This effort is to be opposed by the resistance of the wall, which let us suppose to be collected at c, the centre of pressure, and, reducing it to the direction CE, the effect of friction being allowed for, it becomes $\dfrac{R(F+\tan.a)}{\sec.a}$ (19.)

Hence, in the case of equilibrium,

$$\frac{W(1-F\tan.a)}{\sec.a}=\frac{R(F+\tan.a)}{\sec.a};$$

$$\text{Or, } R=W\left(\frac{1-F\tan.a}{F+\tan.a}\right) \quad (20.)$$

50. But, in the case now considered, the radius being unity, $W=\dfrac{h^2S}{2}\left(\tan.a-\tan.c\right)$. Therefore,

$$R=\frac{h^2S}{2}\left[\frac{(\tan.a-\tan.c)\times(1-F\tan.a)}{F+\tan.a}\right]. \quad (21.)$$

And, from the state of the variable quantities in this equation, it is obvious that it has a maximum value, which determines the angle of fracture. By the principles of maxima and minima, the maximum pressure takes place when

$$\tan a=-F+\left(1+F\tan.c+\frac{\tan.c}{F}+F^2\right)^{\frac{1}{2}} \quad (22.)$$

If the angle which the plane of repose (BRIDGE, Sect. III.) makes with a vertical plane be denoted by i, then $F=\dfrac{1}{\tan.i}$; and $\tan.a=$

$$\frac{-1+(\tan.c.\tan.^3i+\tan.^2i+\tan.c\tan.i+1)^{\frac{1}{2}}}{\tan.i} \quad (23.)$$

If the back of the wall be vertical, $\tan.c=o$, and then this equation reduces to the simple form, which Prony obtained, of $\tan.a=\tan.\frac{1}{2}i$. (24.)

51. When we substitute in equation (21) the value of the tan. a, which has been found in equa. (23), it becomes

$$R=\frac{h^2S}{2\tan.i}\left\{\tan.i+\tan.c.+\frac{2}{\tan.i}-2\left(\tan.c.\tan.i+\frac{\tan.c+1}{\tan.i}+1\right)^{\frac{1}{2}}\right\} \quad (25.)$$

And, when the back of the wall is vertical, it becomes $R=\dfrac{h^2S}{2}(\tan.^2\tfrac{1}{2}i)$. (26.)

The tan. i being the co-tangent of the angle of repose, if the matter to be supported be of so fluid a nature that it naturally assumes a sensibly level surface when at rest, the tan. $\frac{1}{2}i$ becomes equal to unity; and, consequently, $R=\dfrac{h^2S}{2}$ (27.)

The same result may be obtained from the common principles of hydrostatics in the case of fluids.

Since the only variable quantity which enters into the calculation of the distance of the centre of pressure is the height h, whatever the nature of the supported material may be; therefore that distance counted from the base will always be $\frac{1}{3}h$, as in the pressure of fluids. (See HYDROSTATICS, in the *Encyclopædia*.)

52. TABLE IV.—*Table of Constant Quantities necessary for calculating the Pressure of some Materials.*

	Substance.	Angle of Repose.	Weight of a Cubic Foot =S.	Value of R in Equation (26.)	Value of R in Equa. (25) when c=10°.
1	Water	0°	62·5 lbs.	$R=31\frac{1}{4}h^2$	$R=31\frac{1}{4}h^2$
2	Fine dry sand	33°	92 —	$R=13{\cdot}8h^2$	$R=4{\cdot}8h^2$
3	Do. moist	—	119 —	$R=17{\cdot}85h^2$	$R=6{\cdot}2h^2$
4	Quartz sand (dry)	35°	102 —	$R=13{\cdot}77h^2$	$R=4{\cdot}64h^2$

In sand, clay, and earthy bodies, the natural slopes should be taken when the material is dry, and the clay and earth pulverised. When any of these bodies are in a moist state, the parts cohere, and the angle of repose is greater, though the friction be actually less. The preceding Table shows that the pressure of water is greater than that of any of the other kinds of matter, and from the nature of

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fluids it is evident, that if water be suffered to collect behind a retaining wall, calculated to sustain common earth only, it will most likely be overturned. Such accidents may be prevented by making proper drains.

53. The preceding analysis will apply, without sensible error, to the curved walls which have lately become fashionable. Fig. 10 is a section of one of these walls, as executed from a design by Rennie. The vertical height, AB, 21 feet; the wall of uniform thickness, with counterforts 15 feet apart; and the front of the walls described by a 69 feet radius, with the centre in the horizontal line DA produced. The wall is built of brick, and the uniform part is 4·5 feet thick. The radius is usually thrice the vertical height of the wall; when this proportion is adhered to, the angle c will be ten degrees, for which the value of R is calculated in the Table.

Resistance of Walls.

Resistance of Walls.

54. In the first place, we propose to investigate the resistance a wall offers to being overturned; and, in so doing, it appears desirable that the resistance of the mortar in the joints should be considered one of the elements of the strength of the wall. Good mortar adds much to the firmness of walls, and still more to their durability, and, all things considered, its first cost is less than that of bad; besides, the resistance of mortar to compression must be considered, for, in practice, we have no perfectly hard arrises to fulfil the conditions of common mechanical hypotheses.

Put A = the area of the wall.

w = the weight of a cubic foot of masonry.

y = the horizontal distance, ga, between the vertical passing through the centre of gravity of the wall, and the point where the axis cuts the plane of fracture, the same notation being applied to the other quantities as in the foregoing equations.

Let G, fig. 9, be the centre of gravity of the wall; and on the vertical Gg set off gI, the height of the centre of pressure: also, let IK represent $A \times w$ = the weight of the wall, and HI the force R of the earth.

Then, completing the parallelogram, EI will represent the direction and intensity of the straining force; consequently, $\frac{R}{Aw} = \tan. a$ (28.)

Which determines its direction, and its intensity is

$$W = \frac{Aw}{\cos. a} \qquad (29.)$$

But, we have found, equa. (10),

$W = \frac{fbd^2}{d \cos. a + 6l \sin. a + 6y \cos. a}$; and as $W = \frac{Aw}{\cos. a}\Big($Equa. (29.)$\Big)$; $\tan. a = \frac{R}{Aw}$; Equa. (28); $l = \frac{1}{3}h$, art. 51; and b = unity; the equation reduces to $fd^2 - Adw - 6Awy = 2Rh.$ (30.)

If the section of the wall be a parallelogram, then $A = hd$, and $-\frac{1}{2}h \tan. c = y$; these values of A and y being substituted in Equa. (30), it becomes $-whd^2 + fd^2 + 3h^2wd \tan. c = 2Rh.$ (31.)

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$$\text{Or, } d = \frac{h^2w}{f-hw}\left(\frac{-3\tan. c}{2} + \sqrt{\frac{2R(f-hw)}{h^3w^2} + \frac{9\tan.^2 c}{4}}\right). \qquad (32.)$$

When the section of the wall is a rectangle $y = o$, therefore Equa. (31) reduces to

$$d = \sqrt{\frac{2Rh}{f-hw}} \qquad (33.)$$

This last Equation is also correct for a wall of which the back is vertical, and the front sloping. We suppress the investigation, to afford the young student an opportunity of proving that the diminution of weight is exactly counterbalanced by the alteration of the distance of the centre of gravity from the axis.

The tendency of a wall to slide forward may be easily prevented, by giving an inclination to the joints.

55. To illustrate these rules we shall give two examples, and in these show the construction of a table, which the reader may enlarge at his pleasure.

Example I. Let it be required to determine the thickness of a rectangular wall for supporting the front of a wharf 10 feet in height, the earth being a loose sand, and the wall to be built of brick.

The weight of a cubic foot of brick-work may be estimated at 100 lbs., and the resistance of mortar being valued at 5000 lbs. *per* superficial foot, the experimental value being 7900 lbs., Table III. Experiment 42, and the difference an allowance for any irregularity in building, consequently, $f = 5000$; $w = 100$; and by Table IV. $R = 13{\cdot}8h^2$; hence, Equa. (33), $d = \sqrt{\frac{2Rh}{f-hw}} = \sqrt{\frac{2 \times 13{\cdot}8 \times h^3}{5000 - 100h}} = \sqrt{\frac{h^3}{181 - 3{\cdot}62h}}$. When $h = 10$ feet, then the thickness of the wall $d = 2{\cdot}644$ feet. If h be made successively 10, 20, 30, 40, &c. feet, the numbers under the head of dry sand in the following Table will be obtained, observing that they are only calculated to the nearest tenth of a foot.

The proper thickness being found for supporting one kind of material, that for any other may be easily determined; as the thickness varies as the square root of R, Equa. (33). Let the thickness for dry sand be d, then $\sqrt{13{\cdot}8} : \sqrt{31{\cdot}25} :: d : 1{\cdot}5d$ the thickness for supporting water. $\sqrt{13{\cdot}8} : \sqrt{17.85} :: d : 1{\cdot}14d$ the thickness for supporting moist sand. In this manner, by means of Table IV. the thicknesses for other kinds are easily calculated.

Example II. If a retaining wall be intended to support a sandy and loose kind of earth, to be constructed of brick, and to be inclined 10 degrees from the vertical, the thickness being uniform; it is required to determine that thickness for any given height.

By Equa. (32), $d = \frac{h^2w}{f-hw}\Big(-\frac{3\tan. c}{2} +$

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$\sqrt{\frac{2R(f-hw)}{h^3w^2}+\left(\frac{3\tan. c}{2}\right)^2}$ and as $c=10°$, tan. $c=\cdot18$, hence $\frac{3\tan. c}{2}=\cdot27$, and its square $=\cdot0729$. Also $f=5000$, and $w=100$, consequently, $d=\frac{h^2}{50-h}\left(-\cdot27+\sqrt{\frac{2R(\cdot5-\cdot01h)}{h^3}+\cdot0729}\right)$

For sandy earth $R=4\cdot8h^2$, therefore $d=\frac{h^2}{50-h}\left(-\cdot27+\sqrt{\frac{4\cdot8}{h}-\cdot0131}\right)$; and making h successively 10, 20, &c. feet, the numbers obtained will be the same within one-tenth of a foot, as those in the following Table, column 5.

56. TABLE V.—*A Table of the Thicknesses for Retaining Walls, Revetments, Dock-walls, &c.*

Height of Wall.	Thickness of Rectangular Walls to support.			Thickness of Leaning and Curved Walls for supporting Dry Sand, the Angle of Inclination being 10°.
	Water.	Dry Sand.	Moist Sand.	
10 feet	4·0 feet	2·7 feet	3.1 feet	1·1 feet
20	12·9	8·6	9·8	2·8
30	29·2	19·4	22·2	5·2
40	62·5	41·7	47·5	9·2

Our investigation informs us that the mortar of high walls must be of a superior strength; indeed, we know that when its consolidation takes place, under considerable pressure, it is of much greater strength. According to what function of the pressure the strength increases, we have not experiments to determine, and we therefore point out the circumstance to the notice of experimental inquirers.

Construction of Walls.

57. The preceding analysis being confined to the conditions under which the equilibrium could not be disturbed by the pressure, it would be quite unnecessary to consider the phenomena of actual fracture, if it were not for the proof which even these phenomena afford of the defects of the common mode of constructing these walls. The back of the wall is generally formed of inferior materials, hence the technical term *face mortar* and *backing mortar*; but, even with inferior mortar, the workmanship is so carelessly done, towards the back of the wall, that when it fractures a portion is left behind. A moment's attention to the direction of the pressure (see fig. 9) must show the importance of using good mortar, and making good bond at the back of the wall; if any part be neglected it ought to be the middle, which is of least importance, provided the wall be well bound together by cross bond stones.

The strength of a wall to sustain earth will always be greatly increased by any roughness or irregularity in the back of the wall, such as projecting stones or bricks; in stone work it is easy to gain much stability by this means. The friction against a smooth wall must add much to its strength; we have not thought it necessary to include its effect in our calculations; but intend that, with counterforts, it should be considered as a set-off against accidental pressures, &c.*

Counterforts are usually placed at about three times the thickness of the wall apart, and are made of the same width as the thickness of the wall. In fig. 11 is shown a plan for building a wall to sustain the pressure of earth according to the form proposed by Vitruvius, Lib. VI. Cap. IX. And fig. 12 is a plan from Perrault's *Notes*. Various other plans have been proposed, the chief of which Colonel Pasley has collected in his *Course of Fortification;* but most of them have little to recommend them. It seems desirable that every kind of curved work should be avoided; and perhaps that plan which unites the most economy with the greatest stability is shown by figs. 13 and 14, Plate CXIX. The spaces A, A, A, are proposed to be filled with gravel or fragments of stone; the whole of the stone-work to be well bonded; and the front and back wall of that thickness which is best suited for bond, in the kind of material to be employed.

Bond of Walls and Cramps.

Bond of Walls.

58. It is not sufficient to depend entirely upon the cementing power of mortar in the construction of walls; the stones themselves should also be bound together by their disposition. The art of disposing stones for this purpose is called bonding. Part of the longest stones should be employed to bind the wall in length, and the other part to bind it crossways; the former are called stretchers, the latter headers.

Figs. 15, 16, 17, 18, and 19, show various methods of bonding walls; these are selected from Greek and Roman examples. The courses of stone are often irregular, as in fig. 17; and in some works we find both irregular courses and broken ones; that is, such as are intercepted by large blocks of stone. Broken courses should be avoided, because they occasion irregular settlements.

The bond of walls requires to be most carefully attended to in the construction of piers, angles, and, in general, every part exposed to great strain.

On this subject it also may be remarked, that crossing the joints properly is a more effectual means of bonding a wall than that of employing very long stones, unless they be very strong ones. For if a stone exceed about three times its thickness in

* See *Philosophical Magazine*, Vol. LI. p. 401, where the effect of such friction is considered.

length, it cannot be so equally bedded but that it is liable to break from unequal pressure; and the fracture commonly takes place opposite to a joint, and therefore destroys the bond of the wall. This defective mode of construction we have often had occasion to notice.

In works of hewn stone destined to support great pressure, or to bear the action of a heavy sea, it is necessary that the stones should be of great bulk, and connected in the firmest manner. Sometimes this is effected by forming the stones so as to lock them together. The Eddystone and Bell-Rock Light-Houses are bound together at the base on this principle. (See Bell-Rock in this *Supplement.*)

Where less strength is required, iron cramps are used, and sometimes pieces of hard stone are dovetailed into the adjoining blocks. We think cramps of cast-iron might be employed with much advantage in all these cases.

59. The proper quantity of mortar to be employed in stone-work is another point to which it will be useful to direct the mason's attention. A stone cannot be very firmly bedded upon a very thin layer of mortar; and if the stone be of an absorbent nature, the mortar will dry too rapidly to acquire any tolerable degree of hardness (*Vitruvius,* Lib. II. Cap. VIII.), however well it may have been prepared. On the other hand, if the bed of mortar be thicker than is necessary to bed the stone firmly, the work will be a long time in settling, and will never be perfectly stable.

When the internal part of a wall is built with fragments of stone, they should be closely packed together, so as to require as little mortar as possible. Walls are often bulged by the hydrostatic pressure of mortar, when it is too plentifully thrown into the interior, to save the labour of filling the spaces with stones.

The walls of houses are frequently built with hewn stone on the outside, and rubble stone on the inside The settlement of these two kinds of stone-work during the setting of the mortar are so different, that the walls often separate: or where this separation is prevented by bond stones, the wall bulges outwards, and bears unequally on its base. These evils are best prevented by using as little mortar as possible in the joints of the interior part of the wall, and not raising the wall to a great height at one time.

Foundations.

Foundations. 60. The nature of the materials employed in masonry having been considered, and also the methods of uniting them, we have, in the next place, to turn our attention to the nature of those foundations on which it is commonly required to raise permanent structures of such heavy matter.

In founding on dry ground, the nature of the foundation is ascertained without much difficulty. When it is found to be of firm hard rock, that will bear the action of the weather, no particular precautions are necessary; but in all other cases it is desirable to level the trenches to such a depth as will prevent them from being affected by the change of seasons. Frost, we believe, seldom penetrates so low as two feet below the surface (see Climate in this *Supplement*, Vol. III. p. 179); but in clayey ground, the effect of shrinkage, by heat, is often sensible at four feet below the surface; for to that depth the cracks in summer often extend. Consequently, in clay, the depth of the foundations should never be less than four feet, and in heavy buildings, deeper in proportion to the weight they are to support.

In large works it is also necessary to examine the matter, inclination, and thickness of the under strata, particularly when the upper stratum is of inconsiderable thickness. For this purpose, the older writers on architecture, with much propriety, recommend that a well should be dug near the place, to ascertain these points. A knowledge of the inclination and nature of the strata will also be of use in planning drains, a subject of no small importance to the durability and comfort of a mansion.

In soft ground the base of the wall should be made wide, and it may be reduced to the proper thickness by small off-sets or steps, as in fig. 20. On clay or dry sand the breadth at the bottom may be double the thickness of the wall. On compact gravel or chalk the breadth may be to the thickness as 3 is to 2.

If the ground be soft and wet, with a firm bottom within the reach of piles, then piles may be employed with advantage; but they are very likely to rot, in a few years, where the ground is not wet; and, therefore, in the case of soft ground, not sufficiently wet to preserve piles from decay, we should recommend, in preference, a very wide base or footing, well bonded together, with bars of cast-iron, disposed so that one part could not settle without causing the adjoining ones to go down at the same time; and the whole of the base should, for greater strength, be built in the best water cement.

It is a practice with some architects to employ timber beams and planking in such cases, and in consequence of its decay, in many instances it has been necessary to replace the timber with stone and brick at an enormous expense. It should be a maxim in construction, never to employ timber in a permanent structure where it is not either absolutely wet or perfectly dry.

When ground is very soft and wet, and the solid stratum is beyond the reach of piles, a solid mass may be formed to erect the superstructure upon, by means of a grating of timber, planked over. The brick or stone work which is built upon the planking should be joined with a water cement.

When such ground is not absolutely wet, instead of planking we would employ a connected grating of cast-iron, with stone or brick work built in water mortar.

In all these cases the greatest difficulty consists in preventing irregular settlements; and hence the advantage of employing wood or iron to bind the base together, and render it, as far as possible, an inflexible and solid mass.

In all edifices which press perpendicularly on their foundations, the centre of pressure should coincide, as nearly as may be, with the centre of gravity of the surface which sustains it. In wharf walls, ter-

race walls, abutments and piers of bridges, and the like, the resultant of the pressures should fall in the centre of gravity of the surface which supports it.

Foundations are most difficult to manage where the ground is irregular, particularly for highly finished buildings, which are so much disfigured by a small settlement. In such cases we would endeavour to procure an inflexible base by means of cast-iron beams. It is a good plan to form counter arches under the openings, provided these arches be carefully built; but where they are not well built, they yield so much as to be no better than common walling.

Excavating and removing the earth from foundations is frequently a considerable part of the expense of large works; hence the peculiar species of management which will economize this branch of labour, has become an interesting subject of investigation. We intended to give an outline of the manner of treating it, but we find that it would extend this article far beyond its proper limits.

New Method of Founding in Water.

61. Founding in water may be done in various ways; most of them are very expensive, presenting many difficulties in deep and rapid water; we shall confine our attention to this case only. The best method now in use consists in excluding the water from the space to be founded upon by means of a dam, called a coffer-dam, formed by rows of piles, with bricks or clay between the rows. When bricks are used, it is necessary to caulk the interstices between pile and pile. The space is kept clear of water by means of engines, and the foundation deepened, and piled if necessary.

Considering the immense expense and risk of life, which is encountered in excluding water of 30 or 40 feet depth, we shall here propose, for suitable ground, a more economical and safe method, which is adapted for founding piers, abutments, sea-walls, &c.

The space for the foundation being cleared, let the space it is to occupy be inclosed by a single row of piles, driven near to one another, but not so close as is necessary for a dam. The upper ends of these piles must be high enough for a stage to be formed upon them; which should be just above the height of floods or tides as the case may be. From this stage, the ground within the inclosure may be excavated, by means of a machine, formed so as to combine the principle of the field plough with that of the dredging-machine. (See DREDGING-MACHINE in this *Supplement*.)

When the foundation has been cleared to a proper depth by this process, and levelled, the stone-work may be built in courses with a proper bed and joint of water cement. (See Sect. I. art. 22.) A simple machine might easily be contrived for the purpose. If brick be employed instead of stone, it may be done, by forming the bricks into blocks of three feet long, and eighteen inches square, with cement, and using these blocks instead of stones. This method of building with blocks is already in use for constructing sewers in London. When the work is brought to that height which will enable the workmen to proceed in the ordinary manner, either then or afterwards, the piles may be cut off at low-water line, and a cap-sill being fixed upon their tops, they will remain, and serve as a protection to the work below water.

62. For many purposes it would not be necessary to excavate, nor yet to build in courses; for example, let us suppose it to be the pier of a light bridge, the row of piles being driven in an elliptical form, a strong chain should encircle it at one or two places, and the internal space filled with rough stones, thrown in with water cement, to fill the interstices between them. As the cement indurated, the whole mass would become one solid stone. This mode of construction is effected on the same principle as that the French term "*Les Enrochements en Béton*" (Gauthey, *Construction des Ponts*, II. p. 276); and we have the advantage of a much superior cement to any they have employed.

SECT. III.—STONE-CUTTING.

Of the Beds or Joining Surfaces.

63. Before we proceed to explain methods of forming stones to the particular shapes required for arches, vaults, &c., it may be remarked, that the young mason should be extremely careful to avoid making the beds of stones concave or hollow. For, if this be done, in any case where the stones have to bear much pressure, they will flush, or break off in flakes at the joints, and entirely disfigure the work. It is better that they should be slightly convex. In the construction of piers and columns, where perfectness of form is at least as much regarded as strength, this maxim should be carefully attended to. Nothing can be more offensive to the eye than a flushed joint, since it not only deforms, but also gives the idea of want of strength.

Methods of Stone-Cutting.

64. Stone-cutting may be equally well done by various methods; the most certain consists in forming as many plane surfaces to the stone as may be necessary, in such manner that these surfaces may include the intended form, with the least waste of stone, or in the most convenient way for applying the moulds. Upon the plane surfaces thus prepared, the proper moulds are to be applied, and the stone worked to them. It will generally happen that the bed of the stone will be one of the first plane surfaces, and the arrangement should always be made, so that there may be as little reworking as possible.*

Describing Arches.

65. When an arch is square to the face of the wall, the only difficulty is in drawing it to the proper curve. When the arch is circular, it may be described from a centre, unless the centre be very distant; and in that case a method proposed by Dr T. Young † will be found extremely convenient for the mason's purposes. Fig. 21 represents the instrument. Three points in the curve being known, it is easily

* Frezier may be consulted with advantage on this subject. *Coupé des Pierres*. Tome II. p. 14.

† *Lectures on Natural Philosophy*, Vol. I. Plate VI. fig. 83. This instrument might be usefully applied in Ship-building.

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adjusted to the curve, and will also answer as a mould in many cases. AB is a straight bar of any convenient length; at each end, a small roller is fixed by means of two plates of brass; against these rollers the elastic bar CD slides as it adapts itself to a regular curvature, when moved by the screw E. The natural form of the elastic bar is shown by C′ D′, the depth in the middle, H, should be double the depth at either end, and the breadth uniform throughout the length. This bar, when of wood, should be of straight-grained ash, or lance-wood; the latter is best.

An elliptic arch may be described by continued motion, in the following manner. On a straight bar AB, fig. 22, if AC be made equal to the height of the arch, and CB equal to half the span, then if the end A be moved along a straight edge, ED, while the point B moves along another straight edge, FD, the point C will describe an ellipse.* If the bar be made to move on rollers, an arch on a large scale may be easily and accurately described in this way, when a tramnael would become very unmanageable. For other methods, see ELLIPTOGRAPH in this *Supplement.*

To find the direction of the joints, with a radius equal to half the span, from the point K, fig. 22, as a centre describe the arc GH, which determines the points G,H, called the foci. Let it now be required to draw the joint I, join IG, and IH, draw LI to bisect the angle GIH, and it is the joint at I.

A parabolical arch may be drawn very easily on a large scale by means of tangents. Make AE, fig. 23, equal to the rise CA, and join ED and EB. Draw FG parallel to DB, and divide DF and EG (which are equal) each into the same number of equal parts, then join 11, 22, 33, &c., as is shown in the figure; a curve drawn to touch these tangents is a parabola.

Arches are most conveniently drawn on a large scale by means of parallel ordinates; and an extremely simple method of this kind, for a parabolic arch, has been described by Professor Leslie. (*Inquiry into the Nature of Heat,* p. 503.) Let AB, fig. 24, be the span, and CD the height. Divide AB into twenty equal parts, and raise a perpendicular from each point of section. Let CD be 100 by a scale of equal parts, make the next ordinate on each side 99 parts, or 9×11, by the scale; the next pair of ordinates make 96 parts, or 8×12, and so on; those numbers being respectively as the rectangles of the segments into which AB is divided.

To draw the joints of a parabolic arch, let I be a point, at which a joint is to be drawn, fig. 24; draw I*d* parallel to BA; and make DT equal to D*d*; join IT, and make EI perpendicular to IT, which is the joint required.

Gothic Arches.

66. The finest form for a Gothic arch is a cubic parabola; it is easily constructed from its equation. Observing that the vertex of the curve is at the springing of the arch, and making x the abscissa, and y its corresponding ordinate, by the nature of the curve $x = \frac{y^3}{a}$. Now, if we make y successively equal to 1, 2, 3, &c. feet, we shall have $\frac{1}{a} = \overset{\text{I}}{x}$; $\frac{8}{a} = \overset{\text{II}}{x}$; $\frac{27}{a} = \overset{\text{III}}{x}$; $\frac{64}{a} = \overset{\text{IV}}{x}$; $\frac{125}{a} = \overset{\text{V}}{x}$; $\frac{216}{a} = \overset{\text{VI}}{x}$; $\frac{343}{a} = \overset{\text{VII}}{x}$; $\frac{512}{a} = \overset{\text{VIII}}{x}$; $\frac{729}{a} = \overset{\text{IX}}{x}$; &c. To find a, when x is equal to half the span CD, fig. 25, Plate CXX., and $y =$ the height AD; we have $a = \frac{\overline{AD}^3}{CD}$. If it be desirable that the ordinates should be 1—*nth* part of a foot apart, then divide each by the n^3, which gives the dimensions in feet.

Example. In a Gothic building it is proposed to make an arch to an opening 10 feet wide, the height of which is to be 4 feet 6 inches above the springing line. There CD $= 5$ feet, and AD $= 4{\cdot}5$ feet, therefore $a = \frac{\overline{AD}^3}{CD} = \frac{91{\cdot}125}{5} = 18{\cdot}225$. And using this number for a divisor, the ordinates are easily found, by once setting a slide rule, to be,

$\overset{\text{I}}{x} = {\cdot}0548$ feet $\quad \overset{\text{I}}{o} = {\cdot}0068$ feet
$\overset{\text{II}}{x} = .438$ ——
$\overset{\text{III}}{x} = 1{\cdot}48$ —— $\quad \overset{\text{II}}{o} = .185$ ——
$\overset{\text{IV}}{x} = 3{\cdot}51$ ——
$\overset{\text{V}}{x} = 6.86$ —— $\quad \overset{\text{III}}{o} = {\cdot}857$ ——

And dividing the first, third, and fifth, each by 8 (considering $n = 2$), gives the intermediate ordinates; $\overset{\text{I}}{o}$, $\overset{\text{II}}{o}$, $\overset{\text{III}}{o}$. The advantage of this method consists in the facility of setting out the work on either a large or small scale. Every practical man is aware of the trouble of dividing a distance into equal parts, or of performing other geometrical operations on a platform, or floor; but here, by an easy arithmetical operation, this is avoided. Draw the springing line CD, and the middle line AD; and let the line EC be drawn parallel to AD. Beginning at D, make a mark at every 6 inches on DA, and also on CE, beginning at C; then, through these divisions draw the parallel ordinates. Let the abscissas be measured off on these ordinates, from the line CE by a rod divided into feet, tenths and hundredths of a foot. Put a nail in at each point found in the curve, and bend an uniform lath against the nails, and mark the curve.

67. Our next example is for the purpose of show- Arches for large Bridges.

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* See *Edinburgh Review,* Vol. VI. p. 387. A most ingenious extension of the principles of describing curved lines has been lately invented by Mr Joseph Jopling, which promises to be of much use in the arts, as well as a curious subject for mathematical speculation. The system is somewhat obscurely announced in a Pamphlet, entitled *The Septenary System of Generating Curves by Continued Motion.* London, 1823.

Stone-Masonry.

ing the principles of constructing an arch for a bridge, when the span is considerable. In the Article BRIDGE, Prop. S, the equation of the curve of equilibrium is found to be $y = \frac{\frac{1}{2}ax^2 + \frac{1}{12}bx^4}{m}$, for a disposition of the load which has place commonly in bridges. Making x successively 10, 20, 30, &c. feet, we have

$$y_{\mathrm{I}} = \frac{50}{m}(a + 16\tfrac{2}{3}b).$$

$$y^{\mathrm{II}} = \frac{200}{m}(a + 66\tfrac{2}{3}b).$$

$$y^{\mathrm{III}} = \frac{450}{m}(a + 150b).$$

$$y^{\mathrm{IV}} = \frac{800}{m}(a + 266\tfrac{2}{3}b).$$

$$y^{\mathrm{V}} = \frac{1250}{m}(a + 416\tfrac{2}{3}b).$$

$$y^{\mathrm{VI}} = \frac{1800}{m}(a + 600b).$$

$$y^{\mathrm{VII}} = \frac{2450}{m}(a + 816\tfrac{2}{3}b), \text{ \&c. \&c.}$$

The curve of equilibrium being to pass at the middle of the depth of the arch-stones, CB, fig. 26, will be the height $= h$, and AB the semi-span $=$ S; also let the depth of the arch and roadway at the crown, or a, be 7 feet; and suppose the quantity of matter be so regulated by hollow spandrils that $b = \frac{10}{S^2}$. Under these conditions we shall have

$$m = S^2 \left(a + \frac{1}{6}bS^2\right) = \frac{S^2}{2h}\left(7 + \frac{10}{6}\right)$$ If the semi-span be 72 feet, and the height 24 feet, then $m = 936$, and $b = \cdot 00193$. Calculating the ordinates from these data, we shall have

$$y^{\mathrm{I}} = \cdot 375$$
$$y^{\mathrm{II}} = 1 \cdot 52$$
$$y^{\mathrm{III}} = 3 \cdot 5$$
$$y^{\mathrm{IV}} = 6 \cdot 4$$
$$y^{\mathrm{V}} = 10 \cdot 4$$
$$y^{\mathrm{VI}} = 15 \cdot 7$$
$$y^{\mathrm{VII}} = 22 \cdot 4$$
$$\mathrm{AD} = 24 \cdot 0$$

Construct the curve according to these ordinates, and divide it for the arch-stones. The joints should be perpendicular to this curve; but great accuracy is not necessary in this respect, provided the inclination from that perpendicular be considerably within the angle of repose. (See BRIDGE, Prop. Z.)

The joints may be drawn thus, with any radius: from the next division on one side of the joint a describe an arc, and from the next division on the other side, with the same radius describe another arc to intersect the former one, through the intersection and the division a draw the direction of the joint.

To find the depth of the key-stone, let the horizontal thrust $m = 936$ be multiplied by the mean specific weight of a cubic foot of the materials to form the bridge, and calculate the depth by equation (17). Suppose the mean to be 160 lbs. then the horizontal pressure will be 149,760 lbs. and $\frac{fbd}{4} = 149{,}760$; which, considering $b =$ unity, gives $d = \frac{599{,}040}{f}$. For Craigleith stone, No. 15, Table III. the key-stone should be 6 feet deep.

To find the depth of the arch-stones at any other part of the arch, set off Bc equal the depth at the key-stone, and draw bc parallel to a tangent to the curve of equilibrium at the point where the depth is to be determined, then bc is the depth at that point. The depth at a sufficient number of points being found as above, and set off equally on each side of the curve of equilibrium, the form of the intrados will be determined, which may be terminated by a circular arc at the springing; and it is not a little remarkable that the arch, thus described from principle, is a *pointed arch*.

Oblique Arches.

68. When an arch cuts a plane wall in an oblique direction, there is a little more scope for the art of the stone-cutter. But previously to attempting to proceed further, we would recommend the young student to make himself master of the principles of projection, developement, and solid angles. The first section of the Article JOINERY in this *Supplement* is wholly restricted to these principles; all of which being equally applicable to both arts, it will be unnecessary to repeat them in this place.

Let an elliptical arch be supposed to cut a plane wall obliquely, and the wall to be inclined, ABCD, fig. 27, is the plan of the arch; EF a section at right angles to its direction; IH a section at right angles to the line AB. Project the inclined face of the wall, as shown at AO PB, by the method of projecting planes (JOINERY, Sect. 1 and 7); and in doing this it will be found an advantage to produce the joints till they cut the base line EF, because the angles will be set out with greater accuracy from long lines. In the case where the wall is vertical, the section and projection of the face are not required. Next let the soffit be developed, on the supposition that the arch is a polygon of as many sides as there are arch-stones. (See JOINERY, Sect. I. art. 13.) KLMN shows the developement of the soffit or soffit moulds. The form of the bed of each stone is

* Monge, in an elaborate article on the application of Descriptive Geometry to the use of Architects, has drawn a very erroneous conclusion respecting the joints of vaults and arches; for it is the direction of the pressure, and not the form of the soffit, which determines the best direction for a joint; but the views developed in the Article BRIDGE were not known at the time Monge wrote. In other respects, the article of Monge is well worthy of the attention of the mason. See *Géométrie Descriptive*, article 130, 4me ed. Paris, 1820.

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shown by the planes a, b, c, and d, and is thus found, for the joint, 4, draw he and mf parallel to EF, and produce the joint 84 on the developement to cut he in g; set off ge equal to $4i$, and draw ef parallel to 48; then, a line drawn from e through the point 4, will give the bevel at one end, and a line drawn from f through 8 gives the bevel at the other end; its width is equal to $4k$ on the section. As there are no curved parts, except the soffit of the arch, the stones may be worked by means of bevels, without having moulds made for the soffits and beds.*

Oblique or Skew Bridges.

69. When a road crosses a canal in an oblique direction, the bridge is often made oblique. When the angle does not vary more than ten or twelve degrees from a right angle, the arch-stones may be formed as already described; but in cases of greater obliquity, a different principle of construction is necessary. These cases should, however, be avoided wherever it is possible; as, however solid the construction of an oblique bridge may be in reality, it has neither that apparent solidity nor fitness which ought to characterize an useful and pleasing object.

An oblique arch may be constructed on the principle of its being a right arch of a larger span, as is shown in fig. 28. Let ABCD be the plan, and EFGH the corresponding points in the elevation, in this elevation the dotted lines show the parts which would not be seen.

The joints of the arch are supposed to be divided upon the middle section, and therefore drawn to the mean centre K, which corresponds to the point I on the plan.

Divide AD into any number of equal parts, as at 1, 2, 3, &c. and transferring these points to the elevation; describe the arch belonging to each point, and also draw the parallel lines 11, 22, &c. on the plan.

To find the mould for the arris of any joint, as a, draw ab parallel to the base line EF, and from a, as a centre, transfer the distances of the points where the arches cut the joint, to the line ab. Then let fall perpendiculars from the points in the line ab to the lines 11, 22, &c. in the plan, whence we find a, m, n, o, p, in the curve of the mould for the arris of the joint a. The mould for any other joint may be found in the same manner. The ends of the arch-stones will be square to the joints, and $pcde$ will be the mould for one end, and $acdf$ the mould for the other end. It will be of some advantage in working the arch-stones to observe, that the arch-stone being in its place, the soffit should be everywhere perfectly straight in a direction parallel to the horizon.†

Arches in Circular Walls.

70. If it be required to construct an arch in the wall of a circular building, as in fig. 29, where ABCD is the plan of the wall, the elevation EF should be drawn, and the joints in the same manner, as if the arch were in a plane wall. The curved surface of the soffit should be correctly developed by the process described in the Article Joinery, art. 13, and the moulds made of some flexible material; these soffit moulds are shown at a, b, c, &c. The mould for the joint 2 may be found by dividing the joint into any number m, n, &c. parts; and let a perpendicular fall from each point of division to the curved lines representing the faces of the wall on the plan, and from each point in which the curved lines are intersected by these perpendiculars, draw a line parallel to EF. Also, from 2, as a centre, transfer the divisions on the joint to the horizontal line $f2$, and from thence let perpendiculars fall, which will cut the lines that are parallel to EF in the points through which the curves of the mould must be drawn, as shown by the shaded part P on the plan. Any other joint may be described in the same manner. ‡ In the figure, the section is drawn, because it shows somewhat more distinctly the size of the arch-stones; it is not necessary in finding the moulds, except the face of the wall be inclined, a case of very rare occurrence in practice. An arch in a circular wall always has the appearance of a want of strength on the convex side; and when the curvature is considerable, it becomes absolutely insecure.

The method describing the raking mouldings, so as to mitre with horizontal ones, has been explained in the Article Joinery in this *Supplement*, art. 21—24, and the same methods apply in masonry.

Stairs.

71. Respecting the general principles of stairs, we may also refer the reader to Joinery, art. 39, 40, where the proportions of steps, &c. are shown; in masonry the kinds termed geometrical stairs are the only ones which offer any considerable difficulty in the execution.

Each step of a geometrical stair is partly supported by wedging its end into the wall of the staircase, and it is further strengthened by resting upon the step below it. The outward end of a series of these steps is represented by fig. 7, Plate CXVIII.; the line abc shows the form of the joint between two adjoining steps; in the straight part of a flight of stairs, ab is made about an inch, and the part bc is made perpendicular to the soffit of the stair, and of such a depth as may be required for the kind of stone. As this depth is determined by the mean depth necessary to render a stair safe, we shall here give an example of computing the mean depth of a step for Craigleith stone, by

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* Our method is analogous to that called *Biais par abregé* by the French writers. See Frezier, Tome II. p. 133. Other methods are given by Frezier, Simonin, Rondelet, Nicholson, &c. in the works referred to at the end of this article.

† For further information respecting oblique or skew bridges, the reader may consult Gauthey, *Construction des Ponts*, Tome I. p. 390; Chapman, in Rees' *Cyclopædia*, Art. Oblique Arch; and the Article Navigation, Inland, in the *Edinburgh Encyclopædia*.

‡ Other methods are given by Frezier, Nicholson, &c.

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equa. 16 (art. 41). Put w= the greatest uniform load on a square foot, including the weight of the stone itself, = 300 lbs. the horizontal distance between C and D (fig. 6), =10 feet, and the length of the step BD=6 feet, then $\frac{w \times (CD)^2 \times (DB)^2}{f(CD^2+DB^2)} = d^2$, or $\sqrt{\frac{300 \times 100 \times 36}{26,000 \times (100+36)}} = \cdot 55$ feet, the mean depth GH, fig. 7.

That part of a step which is inserted into the wall of the staircase is made about eight or nine inches long for ordinary staircases, but ought to be longer when the steps are longer.

Steps, and landings, and balconies, should be made to bear as evenly and firmly as possible upon their supports; and from a little consideration of the nature of the strains to be resisted in such operations, the mason may perhaps derive some instruction, since a mistaken view of the subject is likely to be attended with serious consequences.

Let AB, fig. 30, Plate CXX., be a step fixed in a wall, CD being the face of the wall, and CA the part inserted in the wall. It will be obvious that the weight of the projecting part, DB, of the step, with any load upon it, will tend to raise the fixed part at A, and to depress it at C. But it will require a less force at A to sustain the step than at any other point between A and D; and the nearer to D, the greater the strain will be, consequently a greater risk of failure. Hence the effectual resistance on the upper side should be at the extremity, A, of the step, and the support at C should be immediately at the face of the wall.

We have often observed in stone stairs, where steps are alternately in straight flights and winding ones, the soffit of the stair to be irregular, with sudden and abrupt changes of form where the winding steps began and terminated. These may always be avoided, by making a developement of the ends of the steps, and forming the abrupt changes into easy curves, as a joiner does the hand-rail of a stair. (See JOINERY, Plate LXXXVII. fig. 35.*)

Writers on Stone-Cutting.

The earliest author on stone-cutting appears to have been Philibert De L'Orme; and in the introduction to the fourth book of his work he remarks, that he had "never heard of any thing that had been written on stone-cutting, either by ancient or modern architects." The labours of De L'Orme on this subject form the third and fourth books of his *Treatise on Architecture*, in folio, Paris, 1567. We shall close this Article with the following list of some other authors on stone-cutting, in the order they were published:

Mathurin Jousse, *Le Secret de l'Architecture*, folio, 1642. Francois Derrand, *L'Art des Traits et Coupé des Voûtes*, folio, Paris, 1643. Abraham Bosse, *Practique du Trait à preuves de M. Desargues*, 1643. J. B. De la Rue, *Traité de la Coupé des Pierres*, fol. 1728; this was a republication of Derrand's work, with additions. Batty Langley, *Ancient Masonry*, folio, London, 1733. Frezier, *Traité des Coupé des Pierres*, 3 tomes 4to, 1737—1739. *Encyclopédie*, Article MAÇONNERIE. *Encyclopédie Méthodique*, MAÇONNERIE, 1785. Simonin, *Traité Elémentaire de la Coupé des Pierres*, 4to, 1792. P. Nicholson, *Carpenters' and Joiners' Assistant*, 4to, London, 1797. J. Rondelet, *Traité Theorique et Practique de L'Art de Bâtir*, Tom. II. 4to, Paris, 1804. (H. H. H.)

Boundaries, Extent, and Divisions.

SUFFOLK, an English maritime county on the borders of the German Ocean. It is bounded on the east by the sea; on the south by Essex, from which it is divided by the river Stour; on the west by Cambridgeshire; and on the north by Norfolk. Its medium length from east to west is forty-seven miles, and its breadth from north to south twenty-seven. The square contents are 1512 miles, or 967,680 statute acres. It consists of two grand divisions, one called the Liberty of Bury, the other the Guildable Land, each of which furnish a distinct grand jury at the county assizes. The next division is into twenty-one hundreds, and these are subdivided into five hundred and twenty-three parishes. The whole county forms a part of the diocese of Norwich.

Population.

The number of houses in 1821 was 42,773, inhabited by 55,064 families; of whom 30,795 were chiefly employed in agriculture; 17,418 in trade, manufactures, or handicraft; and 6851 were not comprehended in either of those classes. The whole number of inhabitants was 270,542; of whom 132,410 were males, and 138,132 females. The increase in population since the preceding census, ten years before, was at the rate of 16 *per cent*.

Soil, Agriculture, and Productions.

Suffolk is generally a level tract of country, in which, as there are few elevations, there are scarcely any extensive prospects. It is, however, tolerably well clothed with trees, but wants running water; most of the streams being very sluggish in their course, and by no means copious. The soil is as various as in other districts of the same extent. On the sea-coast it is in general sandy, but rendered productive by the application of shell marl, which is found in abundance. In the middle of the county, from north to south, called usually *High Suffolk*, which is the larger part, the soil is a tenacious, loamy clay, affording good pasturage for cows, whose butter is chiefly used to supply the London markets.

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* The French methods of constructing stairs differ considerably from those of our own country; but it would extend this article too much to explain them; therefore, the reader may consult the works of Frezier, Rondelet, or Simonin, where he will find these methods detailed.

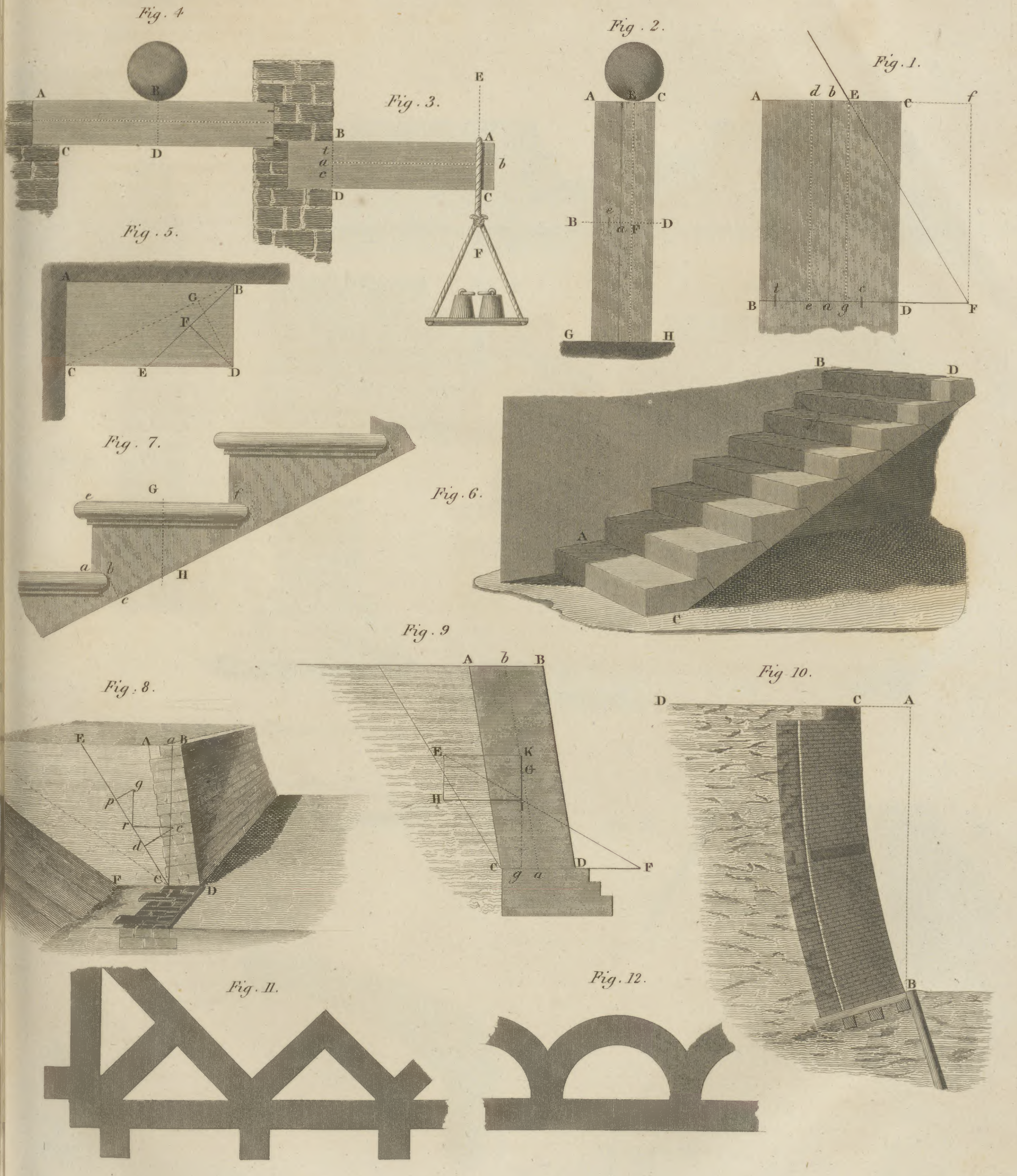

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Fig. 13.

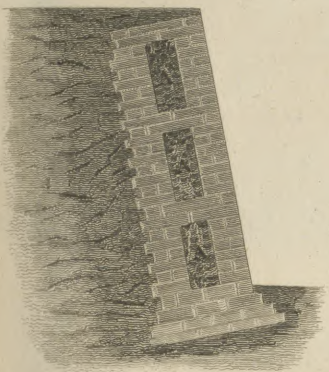
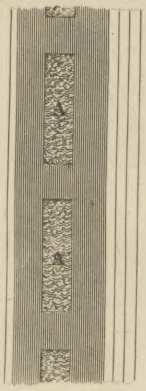


Fig. 14



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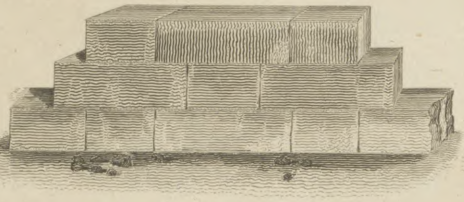

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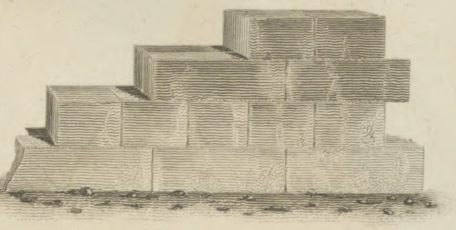


Fig. 18.

Fig. 17.

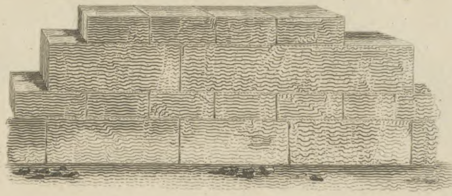
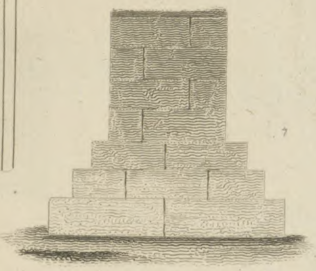


Fig. 20



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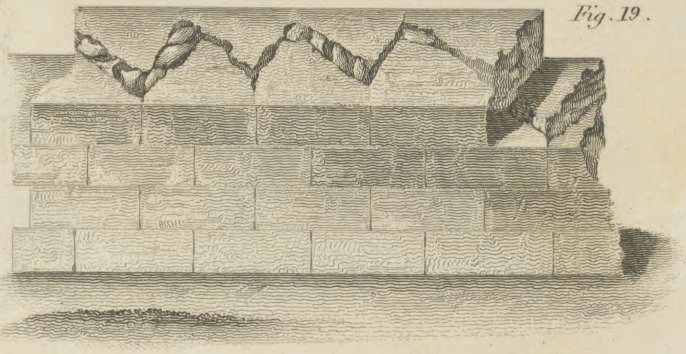

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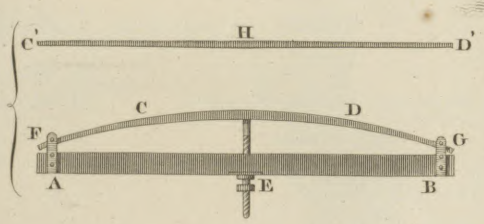

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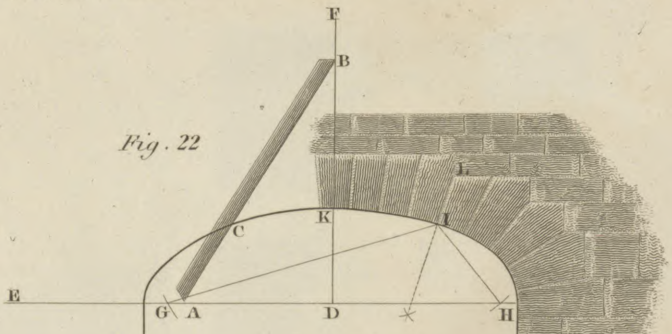

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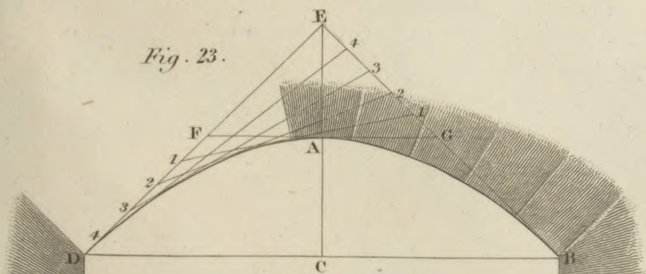

Fig. 24

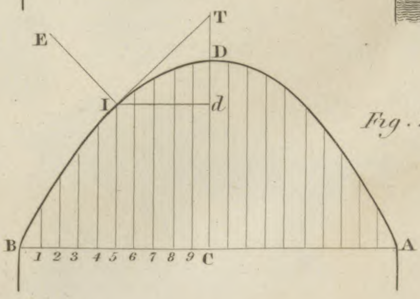

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Fig. 26.

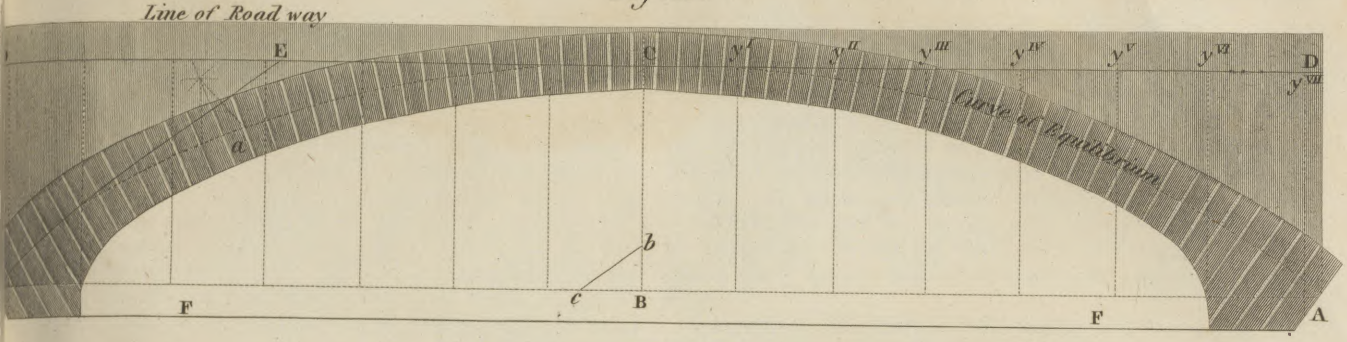


Fig. 27

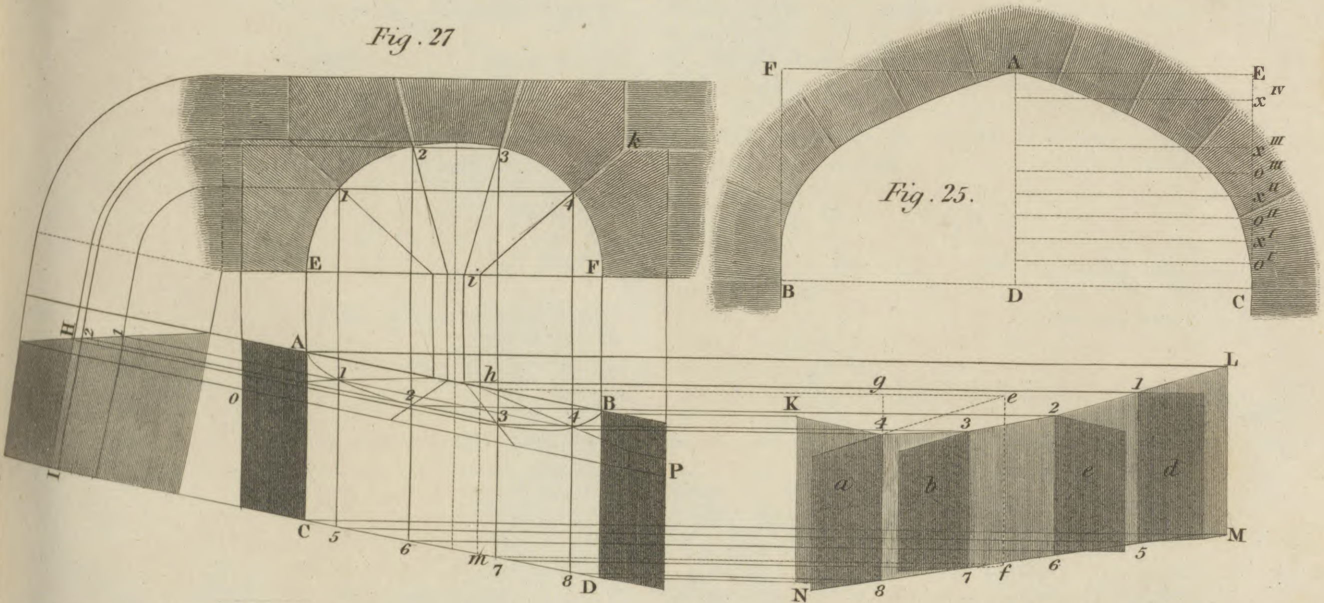
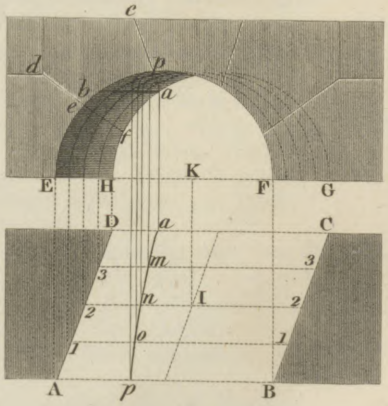


Fig. 25.

Fig. 28.



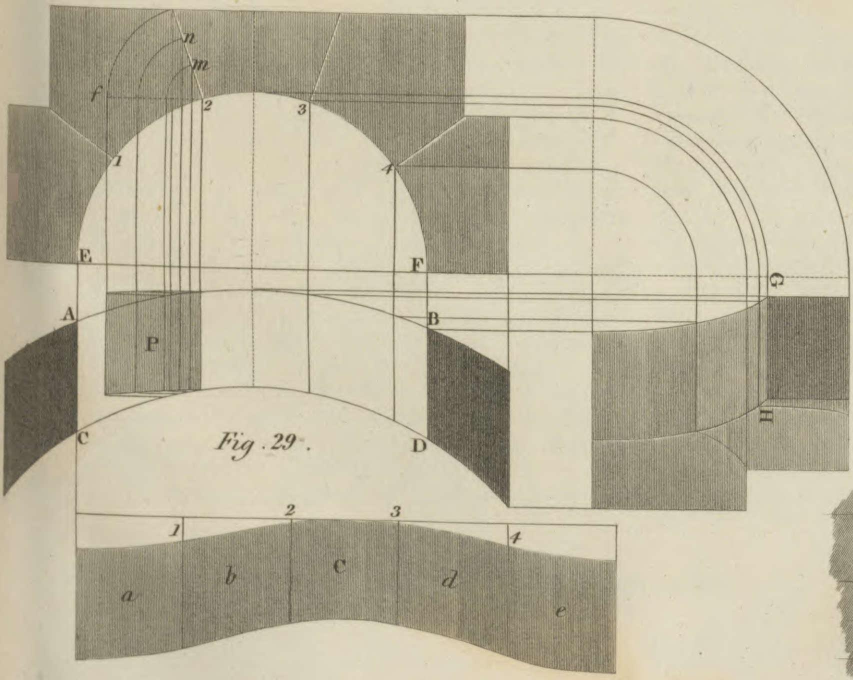
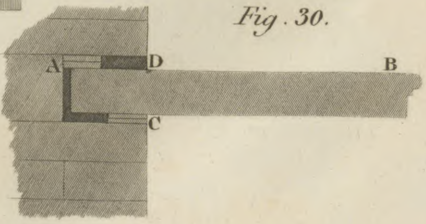


Fig. 29.

Fig. 30.



Suffolk.

The north-western division is a poor sandy soil, in many places covered with heath, and scarcely fit for any other purpose than that of feeding sheep, or breeding rabbits; of which latter animals it is said the skins of more than 40,000 annually supply fur to the hatters. The corn furnished by the eastern division of the county, besides supplying its vicinity, is sent to London from the ports of Ipswich and Woodbridge. The cultivation is commonly conducted on the Norfolk system of turnips, barley, clover, and wheat, and the husbandry being well executed, the crops are generally very good. The beans are peculiarly productive. Turnips, and, in some districts, carrots, are extensively cultivated. Hemp is grown in the garden of almost every peasant, and spun into linen for their domestic uses. Some few hops are grown in the vicinity of Stowmarket.

Cattle.

They have an excellent breed of draught horses, well known by the name of Suffolk *punches*. The cows have been long celebrated for the abundance of their milk, which, in proportion to their size, and the quantity of food which they consume, exceeds the produce of any other race in the kingdom. They are all without horns. The sheep, of which large flocks are kept, are mostly of the Norfolk breed; but, of late years, they have been changed for those of the South Downs.

Manufactures.

There are few manufactures in this county, though it was the first in which the Flemings introduced the clothing trade. Until the extension of machinery in the northern counties, the females found constant winter employment in spinning worsted, but that has ceased. At Stowmarket there is some occupation in making coarse linen for bags, bed-sacking, and other similar uses. At Sudbury there are manufactures of says, and bunting for ships' flags, and of some kinds of silk goods. Near Eye some bone-lace is made. Salt is refined at several places on the sea-shore, from a solution of rock-salt in sea-water.

Fisheries and Commerce.

The branch of industry which, next to agriculture, gives employment to the greatest number of inhabitants, is the fishery. Many vessels are equipped at Lowestoffe and Southwold to take herrings, which are cured in houses appropriated for that purpose in those towns. The taking of mackerel is beneficial before the season when the shoals of herrings arrive on the coast. There is little other commerce in the county than that which arises from the transmission of the agricultural products to the metropolis.

Rivers and Canals.

The navigable rivers are the Lark, which passes by Thetford, and runs to the Ouse. The Deben, of short course, which runs by Woodbridge to the sea; the Orwell, a beautiful river, navigable to Ipswich; and the Blythe, navigable to Framlingham. To these may be added the Waveney, which forms the northern boundary of the county, and the Stour, which is its southern. The only navigable canal is one between Ipswich and Stowmarket.

Landed Property.

The landed property of the county is much divided. There are scarcely any estates so large as to create a decided political preponderance; and there are a larger number of proprietors occupying their own lands, of a value of from L. 100 to L. 400 *per annum*, than in any other county. Except in the heavy clay districts, the farms are generally large, and the tenants being possessed of ample capitals, the agricultural business is admirably conducted. There are neither mines nor mineral springs in this county. In the summer season, sea-bathing attracts a considerable portion of company to the shore at Lowestoffe, Southwold, and some other spots, where every accommodation for such parties is provided.

Antiquities.

Among the antiquities of this county stand first the remains of the ancient Roman castle at Burgh, on the banks of the Yare. It is said to have been the ancient Garianonum erected by Publius Ostorius Scapula, in the reign of the Emperor Claudius. The walls, which are still standing, inclose a space 642 feet in length, and 320 in breadth; they are fourteen feet in height, and nine feet in thickness. The whole ground plan, including the walls, is more than five acres, and is capable of containing a cohort and half; having been built to keep in subjection the Iceni, a people inhabiting Suffolk, Norfolk, Huntingdonshire, and Cambridgeshire. The most remarkable of the Saxon antiquities are the monastery at Bury St Edmund's, that of Framlingham, and several ancient churches.

Titles, and Representation.

The following peers derive their titles from places in this county: Marquis Cornwallis; Earls of Suffolk, Orford, and Stradbrooke; and Baron Rendlesham. The county returns two members to the House of Commons; and two are chosen for each of the boroughs, Ipswich, Bury St Edmund's, Sudbury, Eye, Dunwich, Alborough, and Orford.

The most remarkable seats among a very great number belonging to noblemen and gentlemen in this county, are Euston-Hall, Duke of Grafton; Broom-Hall, Marquis Cornwallis; Ickworth, Earl of Bristol; Henham, Lord Stradbrooke; Boston-Hall, Sir Charles Banbury; Rendlesham, Lord Rendlesham; Benacre, Sir Thomas Gooch; Heveningham-Hall, Lord Huntingfield; Sotterly Park, Miles Barne, Esq.; Flinton-Hall, Alexander Adair, Esq.; Redgrove-Hall, Admiral Wilson; Woolverston-Park, Charles Berners, Esq.; Long Melford, Sir William Parker; Shrubland-Park, Sir William Middleton; and Tendring-Hall, Sir William Rowley.

Principal Towns.

The chief towns and their population are, Ipswich, 17,186; Bury St Edmund's, 9990; Woodbridge, 4060; Sudbury, 3950; Lowestoffe, 3657; Beccles, 3493; Bungay, 3290; Stowmarket, 2252; Mildewhall, 2974; Hadleigh, 2929; Framlingham, 2327; and Halesworth, 2166.

See Kirby's *Suffolk Traveller*. Arthur Young's *General View of the Agriculture of Suffolk*. *Views in Suffolk*, by W. E. Brayley. (W. W.)

SURGERY.

Surgery.

Surgery, rich as it is in sound information, well-established facts, and plans and means for the relief and cure of numberless injuries and diseases, to which the human body is liable, cannot be presumed to have yet reached all the perfection and efficiency of which it is susceptible. Were any doubt entertained upon this point, it would be immediately dispelled by the consideration, that scarcely a year passes away without new and improved modes of practice being suggested, and receiving the sanction of impartial experience. Besides, who can pretend yet to understand every thing relative to a long list of very difficult subjects which enter into the surgical department of the healing art; as, for instance, inflammation, suppuration, cancer, syphilis, scrofula, &c. &c.? Many questions, connected with these and numerous other affections, still remain in the deepest obscurity, presenting an extensive field, in which the diligent and faithful observer may gather immortal fame for himself, and confer infinite and lasting benefit upon the rest of mankind. The great deal that has been done for the advancement of surgery, in the course of the last fifty years, ought to furnish the assurance that much more will be done for its improvement in the half-century that is to come; particularly when the zeal, the emulation, and the ardent love of truth, now presiding over every useful scientific inquiry, are duly contemplated. The design of the present article is, to collect and place before the reader a few of the most interesting novelties in surgery; comprising those which have been produced subsequently to the period when the article upon this subject in the *Encyclopædia* was composed, and others which, though known earlier, escaped notice in that article. In performing this task, we shall take up the subjects in the order in which they present themselves in the original article, to which this is meant to be a supplement.

Of Wens.

The first topic that seems to us to admit of a few additional remarks is that of *encysted tumours*, or *wens*, as they are popularly called. Though tumours and excrescences of various kinds form one of the most frequent classes of diseases, and, what is more, though they often afford convincing illustrations of the efficacy of surgery, the exact causes and manner of their origin cannot be said to have received hitherto any very successful elucidation. In the article referred to, some notice is taken of the interesting opinions of Bichat respecting the production of encysted tumours; and of his refutation of a common notion, that they are not new formed parts, but only dilated cells of the cellular membrane. At the same time, his own particular belief is mentioned, that their formation more probably depends upon laws, which regulate the growth of the different parts of our bodies; which laws, however, not being known and comprehended, leave us as much in the dark respecting the matter in question as if no reference to them had been made. But, what particularly claims our attention here, is the great analogy which Bichat finds between the cysts of encysted tumours and serous membranes; because, if such analogy prevail, it is a strong fact against the correctness of an explanation of the origin of encysted tumours, lately promulgated in this country. Bichat says,—"The cysts, like serous membranes, form a species of sac, *without an opening;* they contain the fluid which they exhale, and they have a smooth and polished surface contiguous to the fluid, whilst the other surface is unequal, and connected with the adjacent cellular membrane." Now, this account is singularly at variance with the doctrine that has been recently proposed by an English surgeon of the highest reputation; who, in his description of the nature of encysted tumours, at least of those which are so frequently seen upon the head, face, and back, and sometimes under the skin of other parts of the body; instead of regarding the cysts as at all analogous to serous membranes, represents them as *dilated cutaneous follicles*, lined with cuticle, and, of course, partaking rather of the character of mucous membranes. Speaking of the origin of encysted tumours, Sir Astley Cooper expresses his conviction, that it depends upon "a follicle extremely enlarged, and incapable of discharging its contents, from an obstruction of the orifice by which it opens upon the surface of the skin." Then, adverting to the nature of follicles, he observes, that, upon superficial examination, they appear to be only pores in the skin; but that, when a small probe is introduced into them, they are found to proceed through the skin into the subjacent cellular membrane. "The first circumstance (says he) which induced me to believe that an encysted tumour was an obstructed follicle, was examining a tumour of this kind situated upon my own back. It had acquired a diameter of about two inches, and was situated at the lower part of the dorsal vertebræ. I thought of requesting a friend to remove it, but, on examining it by means of two mirrors, I saw a small black spot in the centre of the swelling, and by pricking this, I extracted a piece of sebaceous matter with a black head, like those seen in the follicles of the nose. I then squeezed the tumour, and through the orifice occupied by the black sebaceous matter, I emptied the tumour by squeezing out a large quantity of sebaceous substance. This was effected without pain, and without succeeding inflammation; but, gradually, the secretion became renewed; by frequent pressure, however, I have now for several years kept it empty, although the bag and its orifice still remain. A lady applied to me with one of these swellings upon her shoulder. It had a small black spot upon its centre, through which I could squeeze its curd-like contents. I removed it with the skin over it, and found that the opening was a follicle leading into the hollow of an encysted tumour, which contained sebaceous matter, was lined with cuticle, and had a cyst of the usual cha-

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racter. Often have I seen the follicular aperture over these swellings, by which the point of a tent-probe was readily admitted into the cavity of the cyst, and through which I could immediately squeeze its contents. The follicle is, however, generally obstructed at its orifice, and a depression only is seen (and not always even this) when the sides of the swellings are compressed." (*Surgical Essays*, Part II. p. 236.)

This experienced surgeon conceives, that an encysted tumour begins in the following way: a follicle becomes obstructed at its termination upon the skin, and the secretion, still proceeding, its sides are extended in the cellular membrane wherever this most readily yields. If it be inquired, how it is possible for a follicle to be thus extended, the answer is, that other membranes expand to a much greater comparative size. An ovarium, that would not contain within its membrane more than two drachms of water, will expand to a magnitude capable of holding nearly a hundred. The same author also considers pressure, and a want of moisture in a diseased state of the secretions, as occasional causes of encysted tumours. When we first perused Sir Astley Cooper's explanation of the formation of these swellings, a difficulty presented itself to the admission of the doctrine, on account of many encysted tumours being found in situations, where any suspicion of their connection with the follicles of the skin cannot for a moment be entertained. Upon referring to his essay upon the subject, however, we find, that his observations are meant to apply only to the kind of encysted tumour, which is situated just under the skin, and that he acknowledges different species of these swellings. Such difficulty is obviated, therefore, in the particular cases spoken of by this gentleman, as far as the consideration goes upon which it was founded; yet, for various other reasons, the doctrine is not to us, by any means, satisfactory; and it may even be doubted, whether the same mistake may not here have been made respecting the *enlarged follicle*, as surgeons once made about the *dilated cell of the cellular membrane*. That there is a particular class of encysted tumours, having upon their centre a minute dark spot, through which a small probe can be introduced into them, is a fact, which Sir Astley has most correctly described, and he is entitled to the credit of having first made this original observation; but it does not follow, that because there is such a dark spot, or even an aperture, that it must be that of a cutaneous follicle. With respect to the sebaceous substance said to have been pressed out of the opening, some experiments would also be requisite to determine whether it were actually of the same nature as the secretion of the cutaneous follicles. Nor does the occasional presence of cuticle in the cyst prove the truth of the doctrine advanced; because, in the formation of wens, nature presents unaccountable irregularities, sometimes producing in the cyst a substance resembling cuticle, sometimes hair, and, in a few instances, even teeth. The inner surface of almost all the encysted tumours that we have examined, corresponded rather to that of a serous membrane, as explained by Bichat. If encysted tumours arose in the mechanical way, above specified, we should expect them not only to be a much more frequent disease, than they actually are, inasmuch as the cutaneous pores are innumerable, and must very often be obstructed, as we see happen on the nose; but, when the disease is formed, we should expect its cure by the simple removal of the stoppage would be more commonly practicable, than experience shows. Even in the cases which take place near the eye-lids, and have an opening, out of which the contents may be completely pressed, a cure will not follow, unless the cyst be removed. These reflections, at all events, tend to the conclusion, that there must be some other important cause concerned in the production of encysted tumours, besides the mere obstruction of the cutaneous follicles. As the subject, however, is yet obscure, and the new observations upon it come from so high an authority, we have deemed it our duty not to pass them over in silence.

The following practice is adopted by Sir Astley Cooper: If the follicle can be seen only as a black spot, filled with hardened sebaceous matter, a probe is passed through it, and the sebaceous matter squeezed out of the tumour, which may be done with little inconvenience. But, when the contents cannot be pressed out without violence, the preference is given to the plan of enlarging the opening, in order to avoid bringing on inflammation. When an encysted tumour is to be removed, the plan of first making an incision into it is preferred; and the sides of the skin are then pressed together, by which means the cyst, it is said, may be easily everted and removed. This way of operating was recommended for particular cases in the *Encyclopædia*; but doubts may be entertained concerning the advantages of the plan as a general practice.

The removal of encysted tumours is not altogether unattended with danger: Sir Astley Cooper has seen three instances of severe erysipelatous inflammation after operations of this kind upon the head, and one of them ended fatally; one or two other cases, equally unfortunate, have also been reported to us.

In the history of encysted tumours, the curious circumstance of the occasional growth of horny excrescences upon the human body deserves to be noticed: recent investigations prove, that the horny matter is, in fact, the secretion of the cysts of some of these tumours out of which it protrudes, and assumes various shapes, sometimes even that of a ram's horn, as happened in the remarkable case mentioned by Dr Roots of Kingston. This is a subject which has been particularly considered by Sir Everard Home, in the *Philosophical Transactions* for 1791. The case that fell under the observation of Dr Roots may be perused in the Article HORNY EXCRESCENCE, in Dr Rees's *Cyclopædia*. Such horns will be reproduced, if care be not taken in the operation to cut away every particle of the cyst.

Of Erysipelas.

On the subject of erysipelas, the remarks of Mr Hutchison claim attention: he has found seafaring men particularly liable to phlegmonous erysipelas of the legs, frequently occasioned, as he supposes, by the exposure of these parts to the irritation of salt

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water, and the friction of coarse trowsers. In such patients, the disease is said to proceed with extraordinary rapidity to the gangrenous state. Even when mortification is prevented, large abscesses very often form, and spread to a surprising distance between the muscles and under the skin. Now, according to Mr Hutchison's experience, the best way of hindering all these evils, is to make several free incisions into the inflamed surface as early in the disease as possible, the knife being carried through the integuments and down to the muscles. We fear many practitioners will consider this practice severe, more so, perhaps, than circumstances can ever justify in as early a stage as the author speaks of; because, at this period, who can predict, that the case will ever be serious enough to require the employment of the knife? However, as Mr Hutchison never had any unfortunate cases after he adopted the preceding method, and the contrary used to happen under the other plans, which he was formerly in the habit of trying, the proposal appears to deserve mature consideration.

In most works on surgery, little valuable practical information is to be met with respecting the best local applications for erysipelas; the sentiments of the late Dr Bateman, therefore, concerning this unsettled part of practice, may here not be unacceptable. In the early stage of the disease, Dr Bateman found powdery substances, like flour, starch, chalk, &c. increase the heat and irritation, by forming, with the concreting fluid, hard crusts upon the tender surface. In this gentleman's opinion, the only unobjectionable plan is that formerly advised by Dr Willan, which consists in fomenting, or washing the parts, from time to time, with milk, bran and water, or a decoction of elder-flowers. Great benefit is stated to result from tepid bathing, and sometimes from the application of the diluted liquor *ammoniæ acetatis*.

Gonorrhœa.

With regard to the complaint termed gonorrhœa, it seems right just to notice a medicine that has been of late very much employed, and frequently with great benefit. Cubebs, a spice brought from China and Java, is the remedy here spoken of; it has been recommended (no doubt in terms rather too high) as a specific for gonorrhœa, equally proper in the early inflammatory stage, and in the later chronic form of the disease. The dose is a dessert spoonful of the powder, an hour before breakfast, a second six hours afterwards, and a third at bed-time. The powder is to be taken in water. If given while the discharge is copious, and the inflammation severe, the painful symptoms, it is asserted, will be removed in two days, and the discharge will generally cease on the third or fourth day. The antiphlogistic regimen is to be observed, and the powder continued a day or two after the stoppage of the discharge. (See *Edin. Med. and Surgical Journ.* Jan. 1819, p. 61, &c.) Cubebs appears to act upon the mucous membrane of the urethra very similarly to the balsam of copaiva, or turpentine medicines; that is to say, through the medium of the urine, to which it communicates particular qualities, and, amongst them, a powerful smell; its operation, however, is certainly more potent, than that of the above mentioned balsam, and, on this account, it may be sometimes more effectual.

Strictures of the Urethra.

As a supplement to the observations on strictures of the urethra, a short account of the manner of using bougies, armed with caustic potassa, as introduced into practice by the late Mr Whately, may not be uninteresting; and to the same subject we mean to annex a brief description of the way, in which a passage is sometimes forced through bad strictures by means of a catheter of a conical shape; as done at the present day by some surgeons of considerable eminence, particularly in France.

Our reason for introducing an account of Mr Whately's plan of treating strictures, is not that the practice seems to us by any means entitled to the reputation which it acquired, but because there are some surgeons, whose judgment and talents we respect, who think more highly of such treatment, than we could ever yet venture to do ourselves. Mr Whately regarded strictures of the urethra, not merely as contractions, but as really diseased portions of the membrane lining that canal, with a continued disposition to increased contraction. Hence, he conceived, that the remedy should be calculated both to remove the diseased affection, and to dilate the contracted part, without putting the patient to the inconvenience of wearing a bougie. Such a remedy he deemed caustic, when employed with skill and judgment. That to which he gave the preference was the caustic potassa, applied in a particular manner, as being, according to his description, more efficacious, and less painful and hazardous, than bougies armed with lunar caustic.

The following is the practice detailed and recommended by Mr Whately: Before the caustic potassa is used, the urethra should be rendered sufficiently capacious to let a bougie, rather above the smallest size, pass into the bladder, and the irritability of the strictures, if very considerable, should be lessened, in the first instance, by the use of common bougies.

A small quantity of the caustic potassa is to be put upon a piece of paper, and broken with a hammer into small pieces of about the size of large and small pins' heads. When thus broken, it is to be preserved for use in a phial closed with a ground stopper. A suitable curvature is to be communicated to the bougie, by drawing it several times between the forefinger and thumb of the left hand, and it ought to be just large enough to enter the stricture with some degree of tightness. It is to be gently introduced into the urethra, and when its point stops at the stricture, a notch is to be made on the upper portion of the bougie, precisely half an inch from the extremity of the penis. As soon as the bougie has been withdrawn again, a small hole, described as about the sixteenth part of an inch deep, is to be made in its rounded end. Then a bit of the caustic, less than the smallest pin's head, is to be selected for the first application. It is to be fixed in the hole of the bougie with a pocket knife, and pushed into it with the blunt end of a pin, rather below its margin. In order to hinder the caustic from slipping out, the hole is next to be contracted a little with the finger,

and the remaining vacancy filled with hog's lard. The bougie, after being oiled, is to be introduced with its concavity upwards, as far as the anterior part of the stricture, the situation of which has been previously ascertained, and the bougie marked, as already noticed. The instrument should rest there a few seconds, for the purpose of letting the dissolution of the caustic begin to take place; it is then to be very gently pushed towards the bladder, about one-eighth of an inch, when it is again to be kept quiet for a second or two. The bougie is now to be introduced further, in the same gentle manner, until it reaches beyond the stricture. The next business is to withdraw it immediately, by a very gentle motion, to the part at which it was made to rest awhile. Then it is to be very slowly passed through the stricture a second time, but not allowed to stop in its passage. If pain or faintness arise, the operation is now to end, and the bougie to be removed; but if no such consequences occur, the instrument is to be moved backwards and forwards once or twice more.

The foregoing process is to be repeated once every seven days, and if the stricture be found to be dilated, the size of the bougie must be increased accordingly. This method of treating strictures having attained some celebrity, we deemed it worthy of brief notice in the present Work; but our experience leads us to regard the practice as very inferior to that executed with other armed bougies: to the particle of potassa, indeed, we can impute little certain effect, dissolved and blended as it may or may not be with the oil on the end of the bougie, and the mucus of the passage. Its regulation also, in the precise manner described by Mr Whately, so that it may operate exactly on the diseased portion of the urethra, and not upon the sound part, appears to us rather visionary, than really performed. How, then, has the method succeeded at all? Our answer would be, that it has effected cures principally by means of the mechanical dilatation of the bougies, without the potassa having any effect, or at least any that is not much more likely to do harm than good. The practice seems already to be on the decline,—a fact confirming the judgment here delivered concerning it.

We quit Mr Whately's suggestion to make a few observations upon another modern proposal relating to the cure of strictures. Every body, at all acquainted with the history of this disease, knows, that, in France, the use of armed bougies of any kind never met with much approbation, having been there, for the most part, represented as a very dangerous and harsh remedy. Yet, who would have anticipated in this same country, where caustic is abused on the principle of its being a harsh mode of treatment, the origin of another method of cure, in which every thing is to be completed by actual force? Mr Cross, a surgeon at Norwich, who visited the medical schools at Paris for the express purpose of ascertaining the state of the practice of surgery in France at the present day, gives a relation of what he saw there in reference to the treatment of strictures. He informs us, that, when he first went to *La Charité*, there were fifty-three male patients in the surgical ward, amongst whom were five with strictures of the urethra. The caustic bougie, he says, is not used in any of the hospitals, and it was censured by all the surgeons whom he conversed with, as a perilous and harsh remedy. Mr Cross justly observes, however, that the Parisian method of treating many cases of stricture is not milder than the use of caustic. A case is then detailed, which this gentleman saw in *La Charité*. A man, who had had a permanent stricture a long while, had been repeatedly under surgical treatment for it. There was difficulty of making water, but not complete retention. For several days, unsuccessful attempts were made to pass an instrument into the bladder by gentle means. The patient was still able to void his urine, although with great pain and difficulty. M. Roux, the surgeon, now took a conical silver catheter, with a very slight curvature, and an almost pointed extremity, and by means of force, regularly applied, he passed the instrument into the bladder, notwithstanding all obstacles. Care was taken to keep the catheter in a central position, and the direction of its point was judged of by the lateral rings. The rule, laid down by M. Roux, for commencing the great depression of the outer end of the catheter was, when he could feel, by means of his finger in the rectum, that the point had reached the apex of the prostate gland. The patient was put to considerable pain; but the instrument really went into the bladder. The urine was not allowed to flow out immediately, the outer orifice of the catheter being stopped up with a bit of wood. In general, M. Roux suffers the conical catheter to remain in the urethra three or four days; but, the sufferings of this patient from it were so intolerable, that it was taken out in twenty-four hours. Rather a large elastic gum-catheter was then easily introduced, the end of which was fastened to the abdomen, while the orifice was closed with a stopper, and the urine permitted to flow occasionally. The next day, the patient was comparatively easy. On the fourth day, there was a swelling of the testicle, scrotum, and perinæum. A poultice was applied, and the elastic catheter continued. In four days more, the swelling of the parts had subsided so considerably, that the poultice was unnecessary. A fresh gum-catheter of large size was now used, and, in about six weeks, one of the largest dimensions could be introduced.

The event of another case was less fortunate: The *sonde conique* had been employed for making a passage into the bladder, and a gum-catheter afterwards introduced; but, in less than a week, the patient, supposing he could make water without its assistance, withdrew it of his own accord. The next day, an effusion of urine in the scrotum had taken place, and it became necessary to let out the extravasated fluid by two free incisions. Unfortunately, the elastic catheter could not be introduced again. The incisions did indeed prevent sloughing of the scrotum; but the patient, who was in a very reduced state, died in a few days. It is but fair to add, that this case was so inveterate, that Mr Cross believes the patient would have sunk under any mode of treatment. On dissection, the bladder was found to be half an inch thick, the stricture cartilaginous, and extensive sinuses were traced, communicating with the once membranous part of the urethra.

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The promptitude with which relief may be afforded in some very bad cases of stricture, where no bougie, nor elastic catheter, can be introduced, is the reason given for the foregoing practice; and M. Roux even assured Mr Cross, that he had never seen any inflammation or irritation produced by it, that did not readily yield to proper means. We suspect, however, that, by this declaration, M. Roux meant to refer all disastrous circumstances to the disease, when they happened, so as to screen the mode of treatment from all suspicion of being sometimes itself a source of dangerous consequences. Yet, we cannot understand, how he could hope to produce an universal conviction of the accuracy of such an insinuation; because, in his Clinical Lectures, he spoke of two fatal cases, which he dissected, where he found false passages, extravasation of urine, sloughing, &c. amongst other mischief. On the whole, without pronouncing this forcible use of catheters to be always bad practice, we shall venture to say, that it is generally so, and ought very seldom to be attempted. M. Ducamp, an intelligent writer on the present subject, differs altogether from some of his countrymen, by whom the treatment has been carried to a high degree of absurdity. "Surgeons (says he), who are ambitious of the title of *operators*, despise the slow progress and minute attention which the bougies require; nothing but what is prompt, great, and striking, is agreeable to their taste; they thrust a silver catheter through every obstacle into the bladder: at the end of three or four days, they exchange it for one of elastic gum; this last they withdraw every eighth or tenth day, and this they call practising good surgery on a grand scale!" The result is, in general, that a false passage is established, and inflammation of the urethra and prostate is produced by the presence of the instrument. In short, Ducamp clearly shows, from the nature of the stricture itself, that the operation, even when the instrument does not wander from the urethra, does not depend upon dilating the stricture, but upon tearing it; and as the stricture is more resistent than the rest of the canal, the chance is, that a false passage is made.

Having mentioned M. Ducamp, we shall not quit him without recommending to the attention of surgeons, his ingenious contrivances for the application of the lunar caustic to strictures; contrivances which are meant to regulate the action of the caustic more precisely than in the common mode: indeed, the whole of his work deserves, to be consulted. See *Traité des Retentions d'Urine, causées par le Rétrécissement de l'Urètre, et des moyens à l'aide desquels on peut detruire complètement les Obstructions de ce Canal*, Paris, 1822, 8vo.

While we are upon the subject of strictures, Mr Arnott's dilator occurs to us as a very ingenious instrument deserving to be mentioned, though we are not exactly acquainted with the degree in which it has yet been found to answer in practice. It was conceived, that, for the purpose of dilating strictures, an instrument was needed, calculated to pass through the obstruction with facility, then to admit of its diameter being increased to any size, and with any force, yet, when the surgeon wishes to extract it, to be capable of being reduced to its primitive smallness. The dilator consists of a tube of oiled silk, lined with the thin gut of some small animal to render it air-tight, and then fixed upon the end of a small canula, by means of which it can be distended with air or water from a bag, or syringe at the outer end, while a stop-cock or valve serves to confine the air after it has been received. It is said generally to pass as easily down to the stricture as a small bougie; but Mr Arnott sometimes prefers introducing it through a smooth canula, especially when the urethra is irritable, and unaccustomed to the presence of instruments. As soon as the bag is sufficiently within the stricture or strictures, as much air as the patient can easily bear is to be injected into it. The dilator, it is asserted, can be made to act with more effect than a bougie, which, as soon as it yields, loses its power of distention, while the force of the dilator is concentrated at the stricture, and unceasing. In principle, it resembles Bromfield's contrivance for dilating the *meatus urinarius*.

Here the subject of diseases of the urinary passages must not be quitted, without mention being made of the success with which Mr Earle formed a canal, which answered perfectly as a substitute for a considerable portion of the urethra that had been destroyed. The details of this case, which appear to us very interesting, may be perused in the *Phil. Trans.* for 1821.

Of Hydrocele.

To what is delivered concerning hydrocele, in the *Encyclopædia*, a few new and useful observations may be annexed. Since the article on *Surgery* in that work was written, Professor Scarpa has laid down in his valuable treatise upon Hernia some cautions, highly necessary to be recollected by surgeons in the operation of tapping a hydrocele. The analogy, existing between large scrotal herniæ and hydroceles of considerable size, led Scarpa to suspect, that, in the latter disease, a displacement and separation of the vessels of the spermatic chord from each other might also happen. Careful investigations, afterwards made upon the dead subject, fully justified the conjecture. In fact, in all considerable hydroceles, he found the spermatic vessels so displaced and separated, that the artery and vas deferens were commonly situated upon one side of the tumour, and the veins upon the other. Sometimes all these vessels extended over the lateral parts of the tumour, as far as its fore part, principally towards the bottom of the swelling. Now, in numerous examples, the operation of puncturing a hydrocele has been followed by copious extravasation of blood within the tunica vaginalis; but, it was not until within the last few years that Scarpa became acquainted with a case of this kind, sufficiently well detailed and authentic to be quoted as an instance of the spermatic artery being wounded in the operation. Such a fact, however, was at length communicated to him by Gasparoli, an eminent surgeon at Pallanza; who, in introducing the trocar into the lower part of the swelling, wounded the spermatic artery, and the accident terminated in the patient's being obliged to submit to castration. As Scarpa justly observes, the accident may be avoided by taking care to puncture the tumour at a considerable distance from its bottom, that is to say, a little below

its middle, and on a line that would divide the swelling longitudinally into two perfectly equal parts. Experience proves, that, for the purpose of completely emptying a hydrocele, there is not the slightest occasion to make the opening at the lower part of the swelling: the natural corrugation of the scrotum, and a little pressure made with the hand, will suffice for discharging all the fluid contained in the tunica vaginalis, even though the puncture be not lower than the middle of the tumour. These remarks upon the proper method of tapping hydroceles, which are amongst the most frequent cases in surgery, cannot fail to be highly interesting to every practical surgeon, and both on this account, and because they are modern, and perhaps not yet sufficiently known and understood, a short notice of them here appeared to us desirable.

The old method of curing hydroceles by the excision of a portion of the scrotum, and the greater part of the tunica vaginalis, has been very properly rejected from practice; as being an operation of an unnecessarily painful nature, liable to many severe ill consequences. This remark, however, should not be extended to the mode of excision, proposed a few years ago, and practised with success by Mr Kinder Wood: it is indeed a very different proceeding from that which was anciently adopted, inasmuch as it is perhaps the mildest of every plan hitherto devised for the radical cure of this disease, as it simply consists in puncturing the hydrocele with an abscess-lancet, drawing out a little piece of the sac with a tenaculum, and cutting it off. (See *Med. Chir. Trans.* Vol. IX.) If it prove as little subject to failure as the mode of cure by means of an injection, a point yet remaining to be settled in the extensive field of experience, we should say, that Mr Kinder Wood's simple and mild operation is as good a practice as any that has yet been suggested, with reference to the present disease. To us it seems not barely a transient novelty in surgery, but a proposal that may become a solid and lasting improvement.

The cure of an encysted hydrocele of the spermatic chord with an injection, is generally considered by modern surgeons less certain and advantageous, than the excision of a part of the cyst. That judicious and excellent practical surgeon, the late Mr Hey of Leeds, has left some useful observations upon this subject, though he does not appear to be aware, that his method of curing encysted hydroceles of the spermatic chord is substantially the same as that long ago recommended by Bertrandi: it consists in cutting down to the cyst, and removing the fore-part of it, while the portion, closely attached to the cord, is not at all interfered with, by which means, all hazard of doing injury to the spermatic vessels is avoided, and the operation itself shortened.

Diseases of the Synovial Membrane.

The next subject, on which we shall have to dwell a little, is that treated of in the article referred to, under the head of Diseases of the Synovial Membranes. From the observations of Mr Brodie, it appears, that the usual consequences of inflammation of the synovial membrane, or capsular ligament of a joint, are, first, a preternatural secretion of synovia; secondly, an effusion of coagulating lymph into the cavity of the joint; thirdly, a thickening of the synovial membrane, a conversion of it into a substance resembling gristle, and an effusion of coagulating lymph, and probably of serum, into the cellular substance, by which it is connected to the external parts. Mr Brodie has met with several cases, where, from the appearance of the joint and the symptoms, there was every reason to believe, that the inflammation had produced adhesions of the reflected fold of membrane, and in dissection, he has sometimes noticed adhesions, which might have arisen from inflammation at some former period. These effects of inflammation of the synovial membrane, he conceives, bear a strong resemblance to those of inflammation of serous membranes. There are, however, some points of difference. In the former, Mr Brodie thinks, that suppuration rarely takes place independently of ulceration, while, in the latter, this is a frequent occurrence. Some cases have fallen under this gentleman's notice, where there was extensive destruction of the cartilages, apparently in consequence of neglected inflammation of the synovial membrane; but, he believes, that, in most cases, where ulceration of the cartilage is combined with such inflammation, the former is the primary affection, and the latter takes place subsequently, in consequence of the formation of an abscess within the joint. According to the same writer, original inflammation of a synovial membrane seldom happens in young children; but is frequent in adult persons;—the reverse of what takes place in some other diseases of the joints.

Synovial inflammation frequently becomes chronic, and is then liable to be confounded with other more formidable diseases, under the general name of white swelling. The complaint is described by Mr Brodie as frequently proceeding from cold, and being on this account more common in the knee and ankle, than in the hip or shoulder It may also arise from the immoderate use of mercury, and, in particular constitutions, from rheumatism and general debility. In such examples, it often leaves one joint, and attacks another; and it is less severe, and less disposed to produce an effusion of coagulating lymph, or a thickening of the membrane, than when apparently a local disease. In this last case, the disorder is more likely to assume a severe character, and may be of long duration, leaving the joint more or less impaired, and sometimes ending in its total destruction. The following are represented by Mr Brodie as the chief symptoms of inflammation of the synovial membrane: Though, in the beginning, some pain is felt over the whole joint, the patient complains principally of one point, and generally a week or ten days pass, before the suffering attains its greatest severity. Sometimes, even at this period, the pain is trifling; but, frequently, it is considerable, and every motion of the joint distressing. In a day or two after the commencement of the pain, the joint swells, the enlargement arising at first entirely from fluid within the capsular ligament, and where the joints are not covered by much flesh, an undulation may be distinguished. After the inflammation has lasted some time, however, the fluid becomes less perceptible, either in consequence of the synovial membrane being thickened, or lymph effused; and the more solid the swelling is, the more is the mobility of the joint impaired.

The shape of the diseased joint does not correspond to that of the heads of the bones; but, as the swelling is chiefly produced by the distention of the synovial membrane, its figure depends in a great measure upon the situation of the ligaments and tendons, which resist it in certain directions, and allow it to take place in others. Thus, when the knee is affected, the swelling is principally observable on the anterior and lower part of the thigh, where there is only a yielding cellular structure between the extensor muscles and the bone. It is also frequently considerable in the spaces between the ligament of the patella and the lateral ligaments, because at these points the fatty substance is propelled outwards by the fluid. In the elbow, the swelling occurs principally above the olecranon, under the extensor muscles of the fore-arm; and in the ankle, it is between the lateral ligaments and the tendons in front of the joint. In the hip and shoulder, where the disease is not so common, the fluid cannot be felt; but the swelling may be perceived through the muscles. In the beginning of this disease in the hip, a fulness both in the groin and nates may be remarked; but afterwards, the nates become flattened, and the glutæi waste away, from want of exercise. The pain is usually confined to the hip; but Mr Brodie has seen cases, in which it was also referred to the knee. The disease may be discriminated from the case, in which the cartilages of the hip are ulcerated, by observing that the pain is more severe in the beginning than in the advanced stage of the complaint; it never amounts to the excruciating sensation felt in the other disease; and it is aggravated by motion, but not by pressing the cartilaginous surfaces against each other. The wasting of the glutæi is also preceded by a fulness of the nates. After the subsidence of the inflammation, the fluid is absorbed, and the joint frequently recovers its natural figure and mobility; but, in the majority of cases, some stiffness and swelling remain, and the patient continues very liable to relapse, the pain returning and swelling increasing, whenever the patient exposes himself to cold, or exercises the limb much. When the synovial membrane is thickened, a slow inflammation sometimes continues in the part, notwithstanding the absorption of the fluid, and the subsidence of the principal swelling, the disease at length extending to the cartilages, suppuration taking place, and the articular surfaces being completely destroyed. In this advanced stage, the history of the disease, and not its present appearance, is the only thing, by which one can learn, whether the primary affection was inflammation of the synovial membrane, or ulceration of the cartilages. (See Brodie's *Pathological and Surg. Obs.* p. 21, &c.)

In cases where inflammation of the synovial membrane has arisen from an ill managed, or a tedious course of mercury, this gentleman recommends a trial of *sarsaparilla;* and, when it is connected with rheumatism, the medicines praised are opium with diaphoretics, preparations of colchicum autumnale, and other remedies usually prescribed in cases of rheumatism. When several joints have been affected, however, he has known benefit result from moderate doses of mercury.

We need not here enter into a description of the treatment of the acute stage of synovial inflammation; as soon as this is over, the surgeon's aim should be, to remove the thickened state of the capsular ligament; the rigidity of the joint; the pain on motion; the fluid remaining within the capsule, &c. The inflammation having abated, a blister may be applied, and kept open with the savine cerate, or a succession of blisters kept up, as preferred by Mr Brodie. The blisters, he says, should be of considerable size; and, if the joint be deep-seated, they may be applied as near it as possible, but otherwise, at a little distance. Mr Brodie thinks blisters have more effect, than any other means, in removing the swelling; but, excepting in very slight cases, he very rightly condemns their use, unpreceded by bleeding. After the inflammation has sufficiently subsided, exercise of the joint, and stimulating liniments, are recommended. The camphor liniment is to be strengthened with the addition of liquor ammoniæ, or tinctura lyttæ. A very good liniment, much employed by the same practitioner, consists of three parts of olive oil, and of one of sulphuric acid. Mr Brodie has also a favourable opinion of the effects of the antimonial ointment. Plasters of gum ammoniac, he considers, as sometimes useful in preventing relapses. Issues and setons are said to be never serviceable, unless the cartilages are ulcerated. For the removal of the remains of the swelling and stiffness, friction and exercise are set down as the best means. The friction may be made with camphorated mercurial ointment, or with powdered starch; but it is to be adopted with caution, as otherwise it may produce a return of the inflammation. When this is the case, it must be left off, and blood taken from the part. On the whole, Mr Brodie seems to regard friction as more calculated for cases where the stiffness depends upon the state of the external parts, than for others, where it arises from disease in the joint itself. The plan of letting a column of warm water fall on the part is allowed to be sometimes beneficial; but it requires the same caution as friction.

In the article in the *Encyclopædia,* some account is given of the *moveable bodies occasionally found within the synovial capsules,* and the method of cure by an operation is mentioned. This practice, though generally successful, has sometimes brought on severe, and even fatal consequences. Hence, in addition to the observations made upon this subject in the above article, it seems right to state, that the plan of fixing and making pressure on the cartilaginous body has been tried by various surgeons of considerable eminence, as a means of relief. Here we shall only mention the late Mr Hey of Leeds, as an advocate for such practice. Duly impressed with the unfortunate event of some attempts that have been made to cure the disease by the extraction of loose cartilaginous substances from the knee-joint, this judicious practical surgeon preferred trying what relief might be obtained by the employment of a laced knee-cap; and the cases which he has published tend to prove that the plan answers extremely well, the benefit not being temporary, but lasting at least as long as the patient continues the bandage. One of Boyer's patients used a knee-cap a year, at the end of which it

Surgery. was discontinued, and the patient remained free from inconvenience. This practice appears to us to deserve notice, as a safer, though perhaps a less certain plan of relief, than the operation of extracting the substances which are the cause of annoyance.

Spina Bifida. With regard to spina bifida, treated of in the same article, some observations of considerable interest were published a few years ago by Mr Abernethy and Sir Astley Cooper. The first of these surgeons may be said to have the merit of suggesting the principles, on which a few successful attempts at relief have now been made. His reflections upon the nature of the malformation led him to think the trial of a gentle degree of pressure upon the tumour from its commencement extremely plausible; because it might have the effect of promoting the absorption of the fluid, and, at the same time, prevent the distention of the dura mater by keeping it supported. But, if this method were unavailing, and the fluid to increase, Mr Abernethy conceived that, as the disease, now left to itself, would unavoidably soon end in death, it might be a warrantable experiment to let out the fluid by means of a fine puncture, which could be immediately closed with sticking-plaster, and healed by the first intention. He proposed, that an endeavour should then be made to prevent another collection by bandages and topical applications; but, if the swelling returned, notwithstanding such means, he recommended the small puncture to be repeated, and the same mode followed again. We shall not here detail the case, in which Mr Abernethy put the plan to the test of experience, but shall merely state, that, though the child was not ultimately saved, there were circumstances in the case affording a degree of encouragement to future trials of the same kind. Sir Astley Cooper, proceeding on the principles already specified, tried the effect of puncturing spinæ bifidæ with a fine needle, letting out the fluid from time to time, and promoting the closure of the opening in the spine with a compress and bandage. In one case upon record, the treatment in this manner led to a complete cure. (*Med. Chir. Trans.* Vol. II. p. 326.) Sir Astley Cooper, however, follows two methods, according to the circumstances of the case, the one being palliative, the other radical. The first consists in treating the case as a hernia, and applying a truss to prevent its descent; the second in pricking the tumour with a small needle, and producing adhesion of the sides of the sac, whereby the opening in the spine is closed, and the disease altogether prevented. The first is attended with no risk; the second exposes the patient to a great deal of illness; but if successful, hinders the return of the disease. It deserves to be remembered, also, that, when the adhesive process cannot be effectually accomplished by the plan intended for a radical cure, the palliative treatment will yet admit of trial.

In order to be able to practise judiciously in these difficult cases, the surgeon should know, that there are particular examples, which afford not the slightest chance of a cure; they are unfortunately very frequent; for a statement of their nature, the profession is indebted to the last mentioned practitioner. If the tumour is connected with an unnatural enlargement of the head, and hydrocephalus; if the lower extremities are paralytic, or the feces and urine come away involuntarily, there is no hope. Also, if the tumour is burst at the period of birth, or soon afterwards, little expectation of a cure can be entertained. The deficiency of the spine is sometimes so considerable, that the tumour, at the time of birth, is already very large; the nerves protrude from the spinal canal; the medulla itself is injured; and, under these circumstances, all surgical treatment must of course prove ineffectual.

Palsy from Diseased Spine. Palsy of the lower extremities, from a diseased state of the spine, a case considered in the article referred to, has had, of late years, a great deal of attention bestowed upon it; and surely no disease, in the long list of those to which the human body is liable, has a stronger claim to be most carefully investigated, whether the difficulty of cure, or the degree of affliction brought on by the disorder, be contemplated. From Mr Brodie's observations, it would appear, that the affection of the spine is not always of one kind, but that the disease sometimes originates in ulceration of the intervertebral cartilages, and sometimes in a morbid condition of the cancellous structure of the bodies of the vertebræ. This gentleman concurs with Mr Pott, and other writers, respecting the fact, that the actual curvature of the spine must be preceded by disease of this part, unaccompanied with any visible deformity, and cannot take place until caries has made considerable progress. Hence, in the early stage of the case, when the diagnosis is of the highest importance, no information can be obtained from the appearance of the spine itself, the shape of which is yet unchanged; and frequently the symptoms, which do come on early, are rather ambiguous, being, according to Mr Brodie, a pain, and some degree of tenderness in that part of the spine, where the disease has begun; a sense of constriction of the chest; an uneasiness at the pit of the stomach, and over the whole abdomen; a disturbed state of the functions of the alimentary canal, and of the urinary bladder; a sense of weakness and aching, and occasional cramps in the muscles of the extremities. But, it is also acknowledged by the same writer, that very similar complaints may arise from other causes, and sometimes no particular ailments are mentioned previously to the curvature. Mr Brodie is inclined to think that the disease, which begins in the cancellous structure of the vertebræ, is more immediately followed by suppuration, than that which commences in the intervertebral cartilages; and that the first form of the disease seldom produces so extensive a destruction of the vertebræ as the last. But, with the exception of these circumstances, nothing which he has hitherto observed enables him to point out any differences in the symptoms of these different diseases.

The deformity of the spine, as Mr Brodie remarks, is generally of a peculiar kind, and such as nothing can produce, except the destruction of the bodies of one or more vertebræ. The spine is bent forward so as to form an angle posteriorly; and, although the destruction of the vertebræ may be to the same extent, the distortion is more obvious in some parts of the spine than others. For example, the spinous

processes in the middle of the back being long, and projecting downwards, the elevation of one of these must occasion a greater prominence, than that of one of the spinous processes of the neck, which are short, and stand directly backwards.

A curvature of the spine forwards may arise from other causes, as a weak condition of the muscles, or a ricketty affection of the muscles. In such cases, it generally occupies the whole spine, which assumes the shape of a segment of a circle. At other times, however, it occupies only a portion of the spine, usually that which is formed by the superior lumbar and inferior dorsal vertebræ. But, in this circumstance, Mr Brodie finds, that the curvature is always gradual, and never angular; a circumstance distinguishing it from the curvature produced by caries. The cases, he thinks, have often been confounded, and some speedy and complete cures of carious spines on record, he infers, must have been cases of quite a different nature.

Besides the form of disease described by Mr Pott, the observations of the late Mr Wilson prove, that another form commences within the theca vertebralis, and thence extends to the bones. In his lectures at the College of Surgeons, the same gentleman also demonstrated what he called scrofulous tumours in the spinal marrow. Such diseases would create a loss of power in the parts below them, without any curvature of the spine.

We shall not here dwell upon the common treatment of diseased vertebræ, attended with a particular palsy of the limbs; it is already detailed in the former article, and consists principally in keeping open issues near the diseased bones. In France, it seems, the moxa is preferred to caustic issues, and cupping in the vicinity of the disease is often practised.

The great influence of the opinions of Mr Pott concerning the present distemper, has generally kept regular practitioners from making any trial of mechanical means for the support of the spine. It is questionable, however, whether Mr Pott may not have entertained prejudices against machinery, which, under some circumstances, may perhaps be useful. In these cases, mechanical contrivances are never now recommended, under the idea of there being any dislocation; an error sometimes prevailing in former times. We entirely coincide with Mr Brodie, and (we may say indeed) with the great mass of modern practitioners, that machines ought never to be employed with the view of elongating the spine, and correcting the deformity; but, if they be used merely for the purpose of taking off the weight of the head, chest, and upper extremities, from the diseased part of the spine, they may sometimes be of service. No doubt, Mr Brodie is fully justified in the observation, that they ought never, in the first instance, to supersede the constant maintenance of the horizontal position, though they may become advisable, when it is afterwards considered right for the patient to begin to sit up a part of the day.

The good which Mr Pott described as arising in these cases from issues, was imputed by the late Mr Baynton, not in reality to them, but to the long observance of the horizontal posture. Now, although we fully agree, that keeping the patient as quiet as possible in the recumbent position is judicious practice, it does not follow that, because we entertain this belief, we must subscribe to the notion, that issues should be rejected, and that quietude will do every thing. Mr Baynton appears to us to have fallen into an error in supposing, that the process by which the diseased part of the spine is to be restored, and united, should be conducted exactly on the same principles as the union of bones free from disease. The truth is, there is an additional indication, namely, that of checking the progress of the disease, for which purpose experience proves, that issues, aided by rest, are the means affording the best chance of success. That issues frequently do render essential benefit is fully proved by the fact noticed by Mr Brodie, that many patients find themselves improved almost as soon as the issues are made; or regularly experience amendment each time the caustic is applied.

Removal of the Lower Jaw.

To the section on diseases of the bones, in the former article, we deem it right to add a few observations respecting the new and bold operation of removing the lower jaw; a proceeding which has been adopted several times in France by Dupuytren, Lallemand, &c. An interesting case of this practice was detailed a short time ago by the latter gentleman, who is Professor of Surgery at Montpellier. The patient, a robust man, aged 68, was received into the hospital St Eloy, on the 23d of May 1822. Nearly the whole of the lower lip, from one commissure to the other, extending downwards to the lower margin of the chin, was in a state of cancerous ulceration, in which disease the periosteum and bone itself appeared to participate. M. Lallemand began the operation with two semi-elliptical incisions, which commenced in the upper lip, about five or six lines from the commissure, and ended about the middle of the thyroid cartilage. The cheek on each side was dissected up to the front edge of the masseter. In this situation, the periosteum appeared perfectly sound; and here M. Lallemand sawed through the jaw, commencing with the left side. He then detached the muscles and soft parts on the internal side of the bone, and sawed through the right side from behind forwards, as he had done with respect to the left. The labial, submaxillary, and raninal arteries were successively tied, as well as a few less considerable branches. The lower angle of the wound was afterwards brought together with the twisted suture, and the branches of the jaw, and soft parts covering them, approximated by means of adhesive plaster. Soon after the operation, a considerable hemorrhage arose, which could not be suppressed without the actual cautery. In fifty days, the wound completely healed. There was then an interspace of nearly two inches between both ends of the jaw, through which the tongue passed, and the saliva dribbled away. For this last inconvenience, Lallemand contrived a silver chin, upon the concave surface of which was placed a sponge, secured by straps that passed back over the neck. (*Journ. Univers.* December 1822.) It is to be hoped that the successful instances of the removal of the lower jaw, now upon record, may not have the

effect of leading young zealous admirers of every thing in the shape of a new and grand operation to repeat the practice in any cases, where the necessity for it is not clear, urgent, and unequivocal; for with the knowledge that we possess of the great deal that nature will do for the cure of necrosis of this bone, and of the bad, but temporary, disfigurement attending some stages of this disease, we would caution surgeons against any propensity to be too officious in such a case, which may even be erroneously considered as a cancerous affection. It is far from our intention, however, to insinuate, that the above case did not truly demand the bold measure which was put in execution.

Of Aneurismal Diseases.

Since the former Article on Surgery was composed, a great many new and very interesting observations have been made upon *aneurisms;* and the share which English surgeons have had in the modern improvements that have taken place in the treatment of these formidable diseases, reflects such credit upon them, for science, judgment, and enterprise, that, in all works, devoted to the consideration of the diseases of the blood-vessels, their names must be inseparably connected with every successful attempt to meliorate this part of practice, and every praiseworthy effort to throw light upon the nature of the morbid changes to which the arteries and veins are liable. Whoever looks over Hodgson's valuable work on the diseases of the blood-vessels, will find the justness of this encomium completely established; and it is a book to which we refer with considerable pleasure, on account of the perspicuity and correctness prevailing in every part of it.

As an aneurism grows larger, its pulsations become weaker, and when the magnitude of the tumor is considerable, they are sometimes hardly distinguishable. This diminution of the pulsation has been accounted for by the coats of the artery losing their suppleness, in proportion as they become distended, and consequently the aneurismal sac no longer admitting of an alternate diastole and systole from the action of the heart. There can also be no doubt, that the fact is in a great measure owing to lamellated coagulated blood being deposited on the inner surface of the sac. This is an occurrence of great importance; for, when the disease undergoes a spontaneous cure, the deposition of lamellated coagula within the sac, is the mode by which this desirable event is accomplished. As Mr Hodgson remarks, one of the circumstances, which, in the most early stage, generally attend the formation of aneurism, is the establishment of that process, which is the basis of its future cure. The blood, which enters the sac soon after its formation, generally leaves upon its internal surface a stratum of coagulum, and successive depositions of the fibrous part of the blood, gradually diminish the cavity of the tumour. At length, the sac becomes entirely filled with this substance, and the deposition of it generally continues in the artery, which supplies the disease, forming a firm plug of coagulum, which extends on both sides of the sac to the next important ramifications given off by the artery. The circulation through the vessel is thus prevented, the blood is conveyed by collateral channels, and another process is instituted, whereby the bulk of the tumor is removed. (*On the Diseases of Arteries*, p. 114.)

External aneurisms, when they burst, give way by the sloughing of the extremity of a thin conical prominence that is previously formed upon them; but the bursting happens in a different manner in internal aneurisms. As Mr Allan Burns first noticed, these generally burst by actual laceration, and not by the sphacelation of the cyst. But the most correct account of this subject is to be found in Mr Hodgson's work. We are there informed, that when the sac points externally, it rarely or never bursts by laceration, but the extreme distention causes the integuments and investing parts to slough; and upon the separation of the eschar, the blood issues from the tumour. A similar process takes place, when the disease extends into a cavity, which is lined by a mucous membrane, as the œsophagus, intestines, bladder, &c. In such cases, the cavity of the aneurism is generally exposed, by the separation of a slough, which is formed upon its most distended part, and not by laceration. But when the sac projects into a cavity lined by a serous membrane, as the pleura, the peritonæum, the pericardium, &c. these membranes do not slough, but the sides of the tumour having become extremely thin from distention, at length burst by a crack, or fissure, through which the blood is discharged.

A few years ago, Professor Scarpa published a valuable treatise upon aneurism, maintaining the ancient doctrine, that no aneurisms consisted in a dilatation of all the arterial coats, but that they were all attended with a rupture of the proper coats of the vessel, the muscular and internal. Scarpa considers it an error to suppose, that aortic aneurisms, produced by a violent and sudden exertion of the body, or of the heart in particular, and preceded by a congenital relaxation of a certain portion of this artery, or a morbid weakness of its coats, ought always to be regarded as a tumour, formed by the distention or dilatation of the proper coats of the artery itself, that is, of its internal and fibrous coats. On the contrary, he deems it fully demonstrable, that such aneurisms are produced by a rupture of these tunics; and, consequently, by the effusion of arterial blood under the cellular sheath, or other membrane covering the vessel. At the same time, he does not deny, that, from congenital relaxation, the proper coats of the aorta may occasionally yield and be disposed to give way; but he will not allow that dilatation of the vessel precedes and accompanies all its aneurisms, or that its proper coats ever yield sufficiently to constitute the aneurismal sac. The root of an aneurism of the aorta, he observes, never includes the whole circumference of the artery: and the aneurismal sac arises from one side of it, in the form of an appendix, or tuberosity. But what is called a dilatation of an artery, he says, always extends to the whole circumference of the vessel, and therefore differs essentially from aneurism. Hence, he argues, that there is a striking difference between a dilated and an aneurismal artery, although the two affections are sometimes found combined together, especially at the origin of the aorta. It is also noticed, that the dilatation of an artery may exist, without any

organic affection, the blood being always within the cavity of the vessel; that, in an artery so affected, no lamellated blood is deposited; and that the dilatation never gives rise to a swelling of considerable size. In fact, no doubt can be entertained, that these circumstances fully warrant the inference, that aneurism differs essentially from one kind of dilatation of an artery.

According to the observations of Scarpa, the aneurismal sac never comprises the whole circumference of the vessel. Where the tumour joins the side of the artery, the aneurismal sac presents a kind of constriction, beyond which it is more or less expanded. This, he says, would never be the case, if the sac were formed by an equable distention of the tube and proper coats of the affected artery. In incipient aneurisms, at least, the greater size of the tumour would then be in the artery itself, or root of the swelling, while its fundus would be the smallest part. But whether aneurisms be recent and small, or of long standing and large, the passage from the artery is always narrow, and the fundus of the swelling greater in proportion to its distance from the vessel. Scarpa further explains, that the sac is always covered by the same soft, yielding, cellular substance, which, in the healthy state, united the artery to the surrounding parts. In aneurisms of the thoracic aorta, this cellular substance is covered by the pleura, and, in those of the abdominal aorta, by the peritonæum, which membranes include the sac and ruptured artery, presenting externally a continued smooth surface, just as if the artery itself were dilated. But Scarpa observes, that, if the aorta be opened lengthwise on the side opposite the constriction, the place of the rupture of the proper coats of the artery immediately appears within the vessel, on the side opposite to that of the incision. The margin of the fissure, that has occurred, is sometimes fringed, and often indurated, and through it the blood passed into the cellular sheath, which was itself converted into the aneurismal sac. If, as sometimes happens in the arch of the aorta near the heart, the artery, before being ruptured, has been somewhat dilated, it seems, at first, as if there were two aneurisms; but the constriction, which the nearest part of the sac and the artery presents externally, denotes precisely the limits, beyond which the internal and muscular coats of the aorta had not been able to resist the distention, and where, of course, they were ruptured. The partition, which Scarpa asserts may always be seen dividing the tube of the artery from the aneurismal sac, and is lacerated in its centre, consists of nothing but the remains of the internal and muscular coats of the ruptured artery.

Scarpa states, that, when an incision is made lengthwise in the side of the vessel opposite the rupture, its proper coats are found either perfectly sound, or a little weakened, and studded with earthy points, but still capable of being separated into distinct layers. On the contrary, in the opposite side of the aorta, where the rupture is, the proper coats are unusually thin, and not separable from each other without difficulty, or even not at all; they are frequently brittle, like an egg-shell, and are disorganized and torn at the place, where they form the partition between the ruptured artery and the mouth of the aneurismal sac. Continuing to separate these coats from within outwards, we arrive at the cellular sheath surrounding the aorta. As in large aneurisms, this sheath is considerably thickened, and very adherent, at the constriction of the sac, to the subjacent muscular coat of the artery, it is liable to be mistaken for a dilated portion of the vessel itself. But even in such cases, it may at length be separated without laceration from the tube of the artery, above and below the injury, and successively from the muscular coat, as far as the neck of the aneurism. It then becomes manifest that the muscular coat does not pass beyond the partition between the cavity of the artery and that of the aneurismal sac, over which it is not extended, but terminates in a jagged manner at the edge of the rupture. The aorta and the sac being both covered by the pleura, or peritonæum, is a circumstance tending very much to lead surgeons into mistaken views of the real state of things.

As the portion of the aorta within the pericardium is covered only by a thin reflected layer of this membrane, such layer may also give way, when the proper coats of the vessel burst, and the consequence be an instantaneous effusion of blood within the pericardium itself. But every other part of the aorta makes long resistance to the fatal effusion, because there is between it and the peritonæum or pleura, a cellular sheath of a strong and elastic nature, which is capable of expanding into a sac, and while it is strengthened externally by the peritonæum or pleura, its strength is inwardly augmented in a very material degree, by the layers of coagulated blood.

Scarpa's doctrine, that all aneurisms are attended with rupture of the proper coats of the artery, great as the weight and influence of his opinion justly are, is far from having received general or even extensive sanction; for, in France, it is rejected by Richerand, Boyer, Dubois, Dupuytren, Sabatier, Breschet, &c.; and, in this country, every lecturer has continued to adopt the common division of aneurisms into true and false, or into some cases accompanied with dilatation, and into others attended with rupture of the arterial coats. The foundation for Scarpa's sentiments has now been very ably and impartially considered by numerous correct observers; and the love of truth obliges us to confess, that the mass of facts and authorities is decidedly against the doctrine which he maintains, without exceptions. As Mr Hodgson has remarked, the proofs of a partial dilatation of the coats of an artery, particularly of the aorta, are incontestably established by the possibility of tracing the coats of the vessel throughout the whole extent of the expansion, and by the existence of those morbid appearances in the sac, which are peculiar to the coats of arteries.

In the year 1811, this gentleman dissected an aneurism of the aorta. The sac was equal in size to a small melon, and the disease had proved fatal by bursting into the posterior mediastinum, and subsequently into the cavity of the thorax. This aorta exhibited the formation of aneurism in three distinct

stages. The internal coat was throughout inflamed, and presented a fleshy and irregular appearance. At the arch of the aorta there was a dilatation, not larger than the half of a small pea. About two inches lower was a second dilatation, which would have contained a hazel-nut, and immediately above the diaphragm was the large aneurism, which had proved fatal. Mr Hodgson removed that portion of the vessel which contained the smallest dilatation, and he then macerated it until its coats could be separated without violence. The dilatation was found to prevail equally in the three coats of the vessel, and, after being separated, each presented the appearance of a minute aneurism. The second dilatation exhibited the same circumstance in a more advanced stage; the coats of the vessel being, however, more closely adherent to each other than in the natural state. Yet it was perfectly evident that the dilatation comprised all the coats of the vessel, the internal, middle, and external. In the large aneurism, the disorganized internal and middle coats could be traced for some distance into the sac, and then the parts contained in the posterior mediastinum, and the vertebræ, formed the remainder of the cyst. Mr Hodgson has met with this partial kind of dilatation at the division of the carotids and iliacs, in the arteries of the brain, and in almost all the arteries which are subject to aneurism. Partial, as well as general dilatation, he observes, frequently precedes the formation of aneurism in the extremities. A gentleman had a large femoral aneurism, which underwent a spontaneous cure. Upon examining the limb after death, the popliteal artery was found to be thickened and covered with calcareous matter. A small pouch, which would have contained the seed of an orange, originated from the side of this artery, and was evidently formed by a dilatation of the coats of the vessel; for the internal and middle coats could be traced in its circumference, and the former in that situation exhibited the same morbid appearances which it possessed in other parts of the vessel. A man died from the sloughing of an aneurism in the ham: in the femoral artery there was a small aneurism of about the size of a walnut. The external coat was dissected from the surface of the tumour to a considerable extent. The internal and middle coats were plainly dilated, and contributed to the formation of the sac. Their dilatation was gradual, and, after making part of the sac for a considerable distance, they were inseparably blended with the surrounding parts. (See Hodgson's *Treatise on the Diseases of Arteries, &c.* p. 70, &c.)

With respect to differences existing on the pathology of aneurism between Scarpa and other modern writers, they seem to us to be reduced to one question, viz. Whether any of the dilatations on record, alleged to comprehend all the arterial coats, ought, or ought not, to receive the name of aneurism? This eminent professor has always distinctly admitted, that the arteries may be dilated, though the kind of dilatation to which he refers is thought by him, as well as by Mr Allan Burns and Mr Hodgson, to require discrimination in a pathological point of view. Dissection shows, says Scarpa, that the morbid dilatation is circumscribed by the proper coats of the diseased artery; and that the inner surface of the sac, formed by the partial, or total protrusion of the arterial tube, is never filled with polypous laminæ, or layers of fibrine, disposed over each other, which layers never fail to be formed, in greater or smaller quantity, in the cavity of an aneurism. The notion, that these layers of coagula are not met with in small dilatations of arteries, but are found in large expansions of them, he says, is contradicted by numerous careful observations, and especially by a specimen actually before him when he was writing, where a morbid dilatation of the arch of the aorta, in the vicinity of its origin from the heart, six inches in length and five in breadth, was completely free from the lamellated coagula always found in aneurisms. On the contrary, the sac of an aneurism being formed of the parts surrounding the wounded or ruptured artery, and the blood never entering it as a natural receiver, the latter fluid always deposits in it these layers of fibrine, and this sometimes so copiously as to fill the whole cyst. At the same time, it is particularly explained by Scarpa, that, if accidentally furrows or fissures exist on the inside of the morbid dilatation, the fibrine may be deposited in these rough places, but only in them. Such fissures and inequalities of the inner surface of the morbidly dilated artery, he regards strictly as so many beginnings of another disease of the vessel, quite different from dilatation, that is, of aneurism subsequent to dilatation.

Scarpa, in his first publication on aneurism, repeatedly mentions, that the morbid dilatation of an artery constantly extends to the whole circumference of it. But this point seems from the appendix to be renounced; as he now observes, where the morbid dilatation is *partial*, or on one side of the artery, like a thimble, (for, very *frequently*, even in the arch of the aorta, this partial dilatation does not exceed the size of half a bean,) the entrance for the blood into this capsule is as large as the bottom of the sac. Where the dilatation occupies the whole circumference of the arterial tube, the swelling always retains a cylindrical or oval form; and if compressed, it yields very readily, and is found after death much smaller than during life. On the contrary, Scarpa remarks with respect to aneurism, that, whether it be preceded by dilatation or not, it constantly originates from one side of the ruptured artery. The entrance for the blood is small compared with the size of the fundus of the sac; the tumour assumes an irregular shape; yields with difficulty to pressure; retains nearly the same size in the dead that it had in the living subject; and its sac, instead of becoming thinner as the swelling enlarges, or the coats of an artery do when they are simply affected with dilatation, grows thicker the larger the aneurism becomes. According to Scarpa, cases of morbid arterial dilatations are positively incurable; which is not absolutely the fact with respect to internal aneurisms, difficult and rare as such an event may be.

The conclusions, justified by facts, seem to be those laid down by Mr Hodgson. 1*st*, That numerous aneurisms are formed by the destruction of the internal and middle coats of the arteries, and the expansion of the outer coat into a small cyst, which,

giving way from distention, the surrounding parts, whatever may be their structure, compose the remainder of the sac. *2dly*, That the disease sometimes commences with a dilatation of a portion of the circumference of the artery. Such dilatation increases until the coats of the vessel give way, when the surrounding parts form the sac in the same manner as when the disease is, in the first instance, produced by destruction of the coats of an artery.

Whenever an aneurismal sac beats strongly, and for a long while, against a bone, as the sternum, ribs, clavicle, and vertebræ, the bones are, in the end, always destroyed; so that the sac then lifts up the integuments of the breast, or back, and throbs directly under the skin. This effect is referred by all the best modern writers to the action of the absorbent vessels, which, under these circumstances, take away the particles of bone, against which the tumour beats. J. L. Petit found the condyles of the femur, and the upper head of the tibia, nearly destroyed by a popliteal aneurism, and another case, in which the injury of the bone had proceeded to a great extent, is recorded by Rosenmüller. It is correctly noticed by Mr Hodgson, that the carious and corroded state of the bones in aneurism is rarely or never attended with the formation of pus. In this respect, therefore, the morbid change differs essentially from common caries or ulceration of bones. Exfoliation also very rarely accompanies it, from which fact one important practical observation is deducible, namely, that if the aneurism be cured, the bones will recover their healthy state, without undergoing those tedious processes which take place in the cure of caries or necrosis.

Mr Hodgson confirms the remark first made by Dr W. Hunter, and subsequently repeated by Scarpa and others, that cartilage is less rapidly destroyed by the pressure of an aneurism than bone itself.

Aneurisms are much less frequent in women, than men. The following comparative Table, affording information on this point, is contained in Mr Hodgson's work:

	Total.	Males.	Females.
Of the ascending aorta, the arteria innominata, and arch of the aorta	21	16	5
Descending aorta - -	8	7	1
Carotid artery - -	2	2	
Subclavian and axillary -	5	5	
Inguinal artery - - -	12	12	
Femoral and popliteal -	15	14	1
	63	56	7

A common notion amongst surgeons is, that an operation for aneurism should not be undertaken until the disease has continued sufficiently long for the collateral arteries to enlarge, so that the circulation may be more sure of going on in the parts beyond the ligature, and the danger of mortification be lessened. Gangrenous mischief was formerly a very frequent consequence of operations for the cure of aneurism, and constituted the practitioner's chief dread; but, while his mind was anxiously directed to the risk of such an occurrence, and while he was even so much alarmed at it, that he, not unfrequently, recommended amputation of the limb, when the aneurism might have been cured by the ligature, and the member preserved; yet, it never struck him, that the frequency of mortification was generally owing to the bad method of operating, formerly practised in cases of aneurism, and not to the mere stoppage of the flow of blood through a part of the main artery of the limb. We here allude to the severe plan of opening the sac, and turning out the lamellated coagula, previously to the application of the ligature, which, after all, was generally put upon a diseased portion of the vessel; so that, if the patient escaped mortification, he rarely escaped the equally formidable consequence—secondary hemorrhage.

At the present day, operations for the cure of aneurism have reached a great degree of perfection; and, generally speaking, they are mild proceedings, compared with what they used to be in the hands of the older practitioners. The result is, that mortification now much less frequently follows them, and surgeons entertain greater confidence in the powers of nature to supply the limb with blood. Hence, also, some of the most judicious practitioners condemn all delay of the operation, merely for the purpose of affording time for the enlargement of the collateral vessels. Certain it is, that delay often does a great deal of harm, by letting the tumour become so large, and the effects of its pressure so extensive and injurious, that, after the artery is tied, the swelling is frequently attacked with severe inflammation, suppuration, and sloughing, and the patient sometimes falls a victim to what would not have taken place had the operation been performed sooner. Nay, delay may have an opposite effect to that expected by its advocates, with reference to allowing time for the anastomosing vessels to dilate; for, as Mr Hodgson has remarked, the large size of an aneurism is in reality a circumstance which must materially prevent the establishment of a collateral circulation. When the tumour is of immense bulk, it has probably destroyed the parts in which some of the principal anastomosing branches are situated, or may prevent their dilatation by its pressure. Nor can it be doubted, that, where the tumour has been suffered to attain a large size, before an attempt is made to cure it, and where, from this cause, both the neighbouring soft parts and the bone are considerably altered, the completion of the cure, that is to say, the full restoration of the use of the limb, must be far more distant, than in other cases, where the cure is attempted in an earlier stage.

According to Scarpa, the complete cure of an aneurism cannot be effected in whatever part of the body the tumour is situated, unless the artery, from which the aneurism is derived, be obliterated, either by nature or art; and converted into a perfectly solid, ligamentous substance, for a certain extent above and below the place of the ulceration, laceration, or wound. Notwithstanding the general cor-

rectness of this observation, we believe there are exceptions to it in a few aneurisms of the aorta, especially those of its arch, which seem to have been occasionally lessened and cured by Valsalva's treatment, repeated bleeding, very spare diet, &c. Here, we are not to suppose, that the aorta is obliterated at its very beginning; but that the diminution of the quantity of circulating blood, the reduced impetus of this fluid, the lessened distention of the aneurismal sac, the general weakness induced in the constitution, and the increased activity of the lymphatic system, all necessary effects of Valsalva's treatment, have combined to bring about a greater or lesser subsidence of the tumour. Certain facts, recorded by Mr Hodgson, satisfactorily prove, 1*st*, That a deposition of coagulum may take place in an aneurismal sac to such an extent as entirely to preclude the communication between its cavity and that of the artery, from which it originates; 2*dly*, That a sac, thus filled with coagulum, cannot prove fatal by rupture; and, 3*dly*, That the gradual absorption of its contents, and the consequent diminution of the sac, may proceed to such an extent, that the disease shall be cured without any obstruction taking place in the calibre of the vessel, from which it originates.

Both the spontaneous and surgical cures of aneurism have generally two stages; in the first, the entrance of blood into the aneurismal sac is prevented; in the second, the parietes of the artery approach each other, and, becoming agglutinated, the vessel is converted into a solid cylinder. In order that compression may be the means of uniting the opposite sides of the artery, and thus of producing a radical cure of aneurism, the degree of pressure, according to Scarpa, must be such as to place these opposite sides in firm and complete contact, and such as to excite the adhesive inflammation in the coats of the artery. The point of compression must also fall above the laceration, or wound of the artery. Another condition is essential to success; the coats of the vessel, at the place where the pressure is made, must be sufficiently free from disease to be susceptible of the adhesive inflammation. When the arterial coats, round the root of an aneurism, are much diseased, Scarpa considers them as unsusceptible of the adhesive inflammation, although compressed together in the most scientific manner, and even when tied with a ligature. This statement would appear to be corroborated by the following fact: Mr Langstaff amputated the thigh of a person seventy-five years of age; but the vessels were so ossified that they could not be effectually tied, and, in less than twenty-four hours, the patient died from loss of blood. It is generally supposed, says Mr Lawrence, that this condition of the arterial coats is incompatible with their union under the application of the ligature. The opinion should be received, however, with some limitation. In a man fifty-nine years of age, bleeding took place nearly a month after amputation, from an ossified femoral artery; and Mr Lawrence was, therefore, obliged to expose and tie that vessel again for the suppression of the hemorrhage, when he found a hard tube, which cracked immediately after the ligature was tightened; the bleeding, however, never returned. This case is mentioned, not with any view of encouraging surgeons to apply ligatures round diseased portions of arteries, a thing which should always be avoided when possible; but, to make them aware, that the ossified state of an artery, unfavourable as the circumstance may be, is not an absolute and constant prohibition to the successful application of the ligature.

Whenever the treatment by pressure is attempted, the plan should be promoted by repeated bleedings, spare diet, and strict repose in bed. Digitalis may also be prescribed, with the view of lessening the impetus of the circulation. Snow, or powdered ice, is sometimes applied to the tumour, with the design of facilitating the coagulation of the blood within the aneurismal sac, and thus bringing about the obliteration of the cavity of the aneurism and the artery. Ice should be employed, however, with some degree of caution. We learn from Breschet, that, when the swelling is large, the parts very tense, their texture changed, and the skin thin, the practice is likely to accelerate the formation of a slough; and he confirms a remark, made by Mr Hodgson, that some patients cannot continue this treatment longer than a few minutes, while others find it absolutely insupportable.

Modern experience has fully confirmed the fact, that the plan which can be most depended upon for the cure of external aneurism, is that of tying the artery some way from the tumour, in the direction towards the heart. The following general instructions respecting the ligature, have received the sanction of many of the best surgeons in this country.

1. The cord should be thin and round, such a ligature being most likely to effect a clean division of the internal and middle coats of the vessel, and not liable to occasion extensive ulceration and sloughing.

2. The ligature should be tightly applied, in order to insure the complete division of the internal and middle coats of the artery, and to prevent its detachment; it being almost impossible, even with the thinnest ligatures, to cut entirely through a healthy artery.

3. The vessel should be detached from its connection, only so far as is necessary for the conveyance of the ligature underneath it.

4. The immediate adhesion of the wound should be promoted by all such means as are known to promote that process in general. (See Hodgson's *Treatise on Diseases of Arteries*, p. 225.)

The late Dr Jones, in his interesting experiments upon animals, performed with the view of ascertaining the effects of a ligature upon the blood-vessels, made out a fact, which at first raised the expectation that it would lead to a considerable improvement of the operation for the cure of aneurisms. After having assured himself of the correctness of an observation, first made by Desault, that, when a firm ligature is applied to an artery, it causes a division of the internal and middle coats, he discovered, that if such ligature be afterwards removed, an effusion of lymph takes place between the cut surfaces into the cavity of the vessel; and that, if several divisions of the internal and middle coats be thus effected in the vicinity of each other, the effusion of lymph was

sufficiently extensive to obliterate the cavity of the vessel.

Here we see that Jones's experiments did not really justify any hope that a single division of the internal coats of the vessel with one ligature would lead to the obliteration of the tube at the tied part, though the cord were removed immediately after its application. On the contrary, his experiments proved that several ligatures, and several divisions of the inner coats of the vessel with them, were necessary, if they were to be taken away directly after being tightened. However, surgeons overlooked this difference, and their zeal allowed them to form hopes, which, in fact, had no foundation in any of the true results of Dr Jones's experiments. At the same time, it cannot be doubted, that if, immediately after tying the trunk of an artery for the cure of an aneurism, the ligature could be altogether removed, and yet the vessel become obliterated, it would be highly advantageous; as no extraneous substance would then be left in the wound to prevent its union, or increase the chance of secondary hemorrhage, by causing the sloughing, or ulcerative process to extend too far. Suffice it here to state farther, with reference to this scheme, that the trials which have been made of it fully prove that it is ineffectual; a conclusion which might have been drawn from Dr Jones's own experiments. Still the fact of the ligature, though applied only for a moment, bringing on an effusion of lymph within the vessel, and a permanent constriction of it on the part operated upon, continued to keep the attention of surgeons fixed upon the subject; and their genius exerted itself in every possible way to render the new information the means of leading to some great and beneficial change in the operation for the cure of aneurism. In particular, it appeared to Mr Travers, that the want of union was chiefly owing to the circumstance of the opposite sides of the vessel not being retained in a state of contact, so that they might have an opportunity of adhering together. This object is fulfilled by the ligature in the common mode of its application; and for the success of Dr Jones's experiment, it was conceived, it would be sufficient to let the ligature remain on the vessel only until the adhesion were strong enough to resist the passage of the blood through the tube. In short, Mr Travers thought, that if a ligature were applied to an artery, and suffered to remain only a few hours, the adhesion of the inner surface of the vessel would then be sufficiently advanced to insure the permanent obliteration of the cavity of the vessel. The early removal of the ligature, it was hoped, would prove highly advantageous by diminishing the chance of hemorrhage, and facilitating the union of the wound.

The trials which have been made of the temporary application of the ligature for the cure of aneurism, we regret to say, have not had such decidedly favourable results, as to enable us to rank the practice as an established improvement. On the contrary, though some cases treated in this manner have been encouraging, the greater number has been of the opposite description. Sir Astley Cooper operated upon a popliteal aneurism in this way; the flow of blood to the tumour was completely stopped by the ligature for thirty-two hours, and the cord then removed; but the pulsations of the disease returned. A ligature was then applied forty hours longer, at the end of which time no pulsation followed the removal of the ligature; but, on the twelfth day, a considerable bleeding came on, and it was necessary to take up the vessel again. The careful consideration of this and various other cases, and, in particular, the perusal of Scarpa's examples of the practice, have perfectly satisfied us that, however flattering the suggestion deduced from Dr Jones's observations might at first be, the plan of removing the ligature, previously to its natural separation, will never answer in the operation for the cure of aneurism, unless either an obliteration of the arterial tube follow, with reasonable certainty, the taking away of the ligature directly after it has been applied, and it has divided the inner coats of the vessel; or, at all events, unless the ligature can always be withdrawn at a determinate period, and the same obliteration either certainly ensue, or be already complete. All this, too, ought to be effected with such regularity and infallibility in every case, that there would be no chance of the surgeon being obliged to apply another ligature, do a second operation, or cause disturbance of the artery in any manner whatsoever.

Independently of the uncertainty of the period, when the arterial tube is closed by the adhesive inflammation in various patients, it appears that the disturbance of the vessel and wound by the steps necessary for the loosening and removal of the ligature, will ever form an insuperable objection to the practice. Scarpa has some apprehension of this kind himself; for he remarks, " In the act of removing the ligature, there can be no doubt, it is of great consequence that the artery be not rudely handled or stretched. And, indeed, if, on untying the running knot, the subjacent knot could be with the same facility untied, we could not wish for a better mode of performing this part of the operation. But the knot, although a simple one, is not so readily untied as the running knot; on account of the moisture with which the threads forming the ligature are soaked, or because the ligature has been previously waxed." These apprehensions lead him to suggest the scheme of placing a thread longitudinally on each side of the cylinder of linen, interposed by him between the knot and the artery. This he does before the knot is made; and at the time of removing the ligature, the threads are to be drawn in opposite directions, in order to undo the knot without displacing or stretching the artery. Thus, instead of one small ligature, which is all that an English surgeon leaves in the wound, Scarpa recommends his ligature of four or six threads, a roll of linen, and two other threads; a quantity of extraneous substances, which cannot fail to be a source of serious irritation and mischief. Were there, however, only the following single objection to this practice, it would never be established in this country; its advocates are necessarily obliged to renounce the infinite advantage of bringing the edges of the wound together directly after the operation. If it had been practicable to withdraw the li-

gature as soon as the inner coats of the vessel had been divided by it, and the obliteration of the momentarily constricted portion of the artery followed as a matter of certainty, the case would have been very different, as there would then have been no foreign body at all left in the wound; the parts might have been immediately brought together, so as to leave the greatest chance of union by the first intention, and no future disturbance either of the artery or of the wound would have been incurred.

In the section upon the popliteal aneurism, in the former Article, two things are recommended, which the experience of many of the best surgeons does not at present sanction. The first is the application of a double ligature, and then dividing the vessel at a point between the two cords; the second is using a ligature of sufficient thickness to hinder it from cutting through the coats of the vessel. With respect to the first of these proceedings, it seems to be of great antiquity, but had fallen into oblivion, when again brought into notice by Mr Abernethy. The reflections which led this gentleman to revive the practice were ingenious; for, when the artery was tied with two ligatures, and divided in the interspace between them, it was argued, that it would be quite lax, possess its natural attachment, and be as nearly as possible in the same circumstances as a tied artery upon the face of a stump. Strictly speaking, however, as Mr Hodgson first pointed out, an artery tied in two places, and cut through in the interspace, cannot be regarded as placed exactly in the same condition as an artery tied in amputation. In the latter case, the retraction of the vessel corresponds with that of the surrounding parts, which are divided at the same instant, and therefore its relative connections stand as before the operation. But, in the operation for aneurism, the retraction of the artery takes place without being attended with a corresponding retraction of its connections. How far the retraction of the artery is beneficial or injurious, is by no means evident; and the advantages arising from it may be obtained in most situations by simply placing the limb in a bent position, without dividing the vessel. One important object, however, is gained by the division of the artery; namely, that in this case it is generally tied close to its connections, and it is very evident how liable the application of the ligature, in the middle of a denuded extent of the vessel, must be to produce ulceration, or sloughing of its coats. The same object, however, will be gained by tying the undivided artery close to its connections, at the end nearest to the heart; and the presence of a single ligature at the bottom of the wound will be less liable to give rise to suppuration, and the formation of sinuses, than the employment of two. When an artery is divided, the portions situated beyond the ligatures must slough, and be an additional cause of suppuration in the wound. Experience has amply proved, as Mr Hodgson correctly states, the safety of employing a single ligature, and it is at present preferred by many of the most experienced operators in this country.

The second thing recommended in the section upon the popliteal aneurism; namely, the use of a largish ligature, with the view of not cutting the coats of the vessel, is a plan which by no means corresponds with the valuable doctrines inculcated by the late Dr Jones in his excellent work upon hemorrhage; nor is it found to be advisable on any practical grounds. On the contrary, the advantage of lessening, as much as possible, the quantity of extraneous substance in the wound, and the manner in which the dividing the inner coats of the vessel by the ligature insures the effusion of lymph within it, and the quick obliteration of its cavity, are considerations which dictate the propriety of always employing a round and slender, but very firm ligature, made of such materials as will combine these properties in the greatest degree. A larger ligature than is absolutely necessary, must ever be disadvantageous, not only by being less calculated, than a smaller one, to cut through the inner coats of the vessel, but by acting as a source of considerable irritation at the bottom of the wound; whereby the healing process, with respect to the wound itself and the tied part of the artery, must be placed in less favourable circumstances.

A few years ago, Mr Lawrence extended to operations for aneurism the plan of tying the artery with a very firm, small, silk ligature; the whole of which is immediately afterwards cut off, with the exception of the noose and knot; and an attempt is then made to heal the wound by the first intention. When this plan is adopted, it is of importance to use a ligature made of dentists' silk, and not catgut, and other substances, which are less fitted for the purpose. Every case, in which any deviation in this respect is made from the directions given by Mr Lawrence, cannot be received as a fair trial of the practice.

Various pincers and compressors have been devised by different surgeons, as means well calculated to obliterate the artery; and, in the opinions of the inventors, they accomplish this business more certainly and securely, than a ligature. Some of these contrivances may, indeed, answer better than the large clumsy cords which are sometimes employed, accompanied with the further irritation and dangers of what are called ligatures of reserve; but all the best surgeons in this country unite in a decided preference to the ligature when of proper construction and skilfully applied. As Scarpa justly observes, metallic instruments, designed to be applied directly to an exposed artery, for the purpose of obliterating it by compression, are liable to all the inconveniences which are inseparable from the presence of hard bodies, introduced and kept for several days in the bottom of the wound; particularly of a recent wound, where they cannot be retained in a proper direction without difficulty, or precisely at such a depth as will not be attended with hurtful pressure upon the wound itself, and the important parts in its vicinity. And, with regard to Asalini's forceps, Monteggia has observed, that, if the obliteration of the artery is retarded, the forceps divides the artery just like the ligature, by causing the death of the included portion. In one case, the same surgeon also saw the extremity of the instrument resting at the bottom of the wound upon the subjacent

femoral vein, the anterior half of which it ruptured, though such portion had not been taken hold of by it.

As a recent improvement in the operation for popliteal aneurism, that of making the incision somewhat higher up the thigh, than was commonly the practice a few years ago, deserves to be noticed. For this suggestion, we are principally indebted to Scarpa, some of whose other measures in the operation seem to us far less deserving of imitation. "The surgeon," says Scarpa, "is to explore with his fore-finger the course of the artery from the crural arch downwards; and, when he comes to the place where the vibration of the vessel begins to be less distinctly felt, this point is to be fixed upon for the lower end of the external incision. This angle of the wound will fall nearly on the inner edge of the sartorius, just where this muscle crosses the track of the femoral artery, and at the very apex of the triangle formed by the convergence of the triceps and vastus internus. A little more than three inches above the place here fixed upon, the surgeon is to begin with a convex-edged bistoury the incision through the integuments and cellular substance, and carry the wound down the thigh in a slightly oblique line from without inwards; so as to make it follow the course of the artery as far as the apex of the triangle already specified, or the point where the vessel passes under the inner edge of the sartorius muscle." Scarpa's reason for making the incision higher up in the thigh than Mr Hunter did, is to avoid the necessity of removing the sartorius muscle from its position, or of turning it back, in order to get at the artery. We have seen the best operators, and even professors of anatomy, perplexed by having the sartorius muscle immediately in their way after the first incision had been made; and, as the vessel is more superficial a little higher up, the place is farther from the diseased portion of the artery, and the method does not interfere with the profunda, which arises about an inch and a half, or an inch and three quarters, below Poupart's ligament, the practice seems to us on every account right and unobjectionable.

Subsequently to the period when the former Article on SURGERY was written, the operation of tying the external iliac artery, for the cure of femoral aneurisms, has been repeated with a degree of success, that the most ardent practitioners could scarcely have anticipated. Indeed, as far as our observations and inquiries extend, it is an operation attended with nearly, if not quite as much success, as that of taking up the artery in the thigh for the cure of popliteal aneurism. Out of twenty-five cases, we know of only three in which the limb was attacked with gangrene. The proportion is not so much as one in eight.

The following is Sir Astley Cooper's method of performing this operation. A semilunar incision is made through the integuments in the direction of the fibres of the aponeurosis of the external oblique muscle. One extremity of this incision will be situated near the spine of the ilium; the other will terminate a little above the inner margin of the abdominal ring. The aponeurosis of the external oblique muscle having been exposed, is to be divided throughout the extent, and in the direction, of the external wound. The flap, which is thus formed, being raised, the spermatic cord will be seen passing under the margin of the internal oblique and transverse muscles. The opening in the fascia, which lines the transverse muscle, through which the spermatic cord passes, is situated in the mid-space between the anterior superior spine of the ilium and the symphysis pubis. The epigastric artery runs precisely along the inner margin of this opening, beneath which the external iliac artery is situated. Hence, if the finger be passed under the spermatic cord, through this opening in the fascia, it will come into immediate contact with the artery, which lies on the outside of the external iliac vein. The artery and vein are connected together by dense cellular membrane, which must be separated to enable the operator to pass a ligature by means of an aneurism-needle round the former of these vessels. (See Hodgson's *Treatise on Diseases of Arteries, &c.* p. 421.) In this operation, as well as in all others for aneurisms, a single ligature is now mostly preferred by all the best surgeons of this country.

Perhaps, no branch of surgery has received so much attention and decided improvement during the last twenty years, as that which has for its object the cure of aneurismal diseases. Cases formerly abandoned as certainly fatal, or in which the patient was saved only by amputation, are now cured, and this without any severe mutilation, or irremediable disfigurement. Nay, aneurisms, seemingly almost out of the reach of the surgeon's hand, are now not relinquished as a matter of course, but every possible means of checking and removing the disease is considered; and the boldest operations, conceivable by the most enterprising surgeon, are planned and undertaken. One proof of this advancement of modern surgery we find in an operation that has now been performed with success in two examples; we allude to that of *tying the internal iliac artery* for the cure of aneurisms of the gluteal artery. This proceeding, which was not before the public at the time when the former article came out, was first adopted by Mr Stevens, a surgeon at Santa Cruz. "An incision, about five inches in length, was made in the left side, in the lower and lateral part of the abdomen, parallel with the epigastric artery, and nearly half an inch on the outer side of it. The skin, the superficial fascia, and the three thin abdominal muscles, were successively divided; the peritonæum was separated from its loose connection with the iliacus internus and psoas magnus; it was then turned almost directly inwards, in a direction from the anterior superior spinous process of the ilium to the division of the common iliac artery. In the cavity which I had now made (continues Mr Stevens), I felt for the internal iliac, insinuated the point of my fore-finger behind it, and then pressed the artery betwixt my finger and thumb. Dr Lang now felt the aneurism behind; the pulsation had entirely ceased, and the tumour was disappearing. I examined the vessel in the pelvis; it was healthy, and free from its neighbouring connections. I then passed a ligature behind the artery, and tied it about half an inch from

its origin. The tumour disappeared almost immediately after the operation, and the wound healed kindly. About the end of the third week the ligature came away, and in six weeks the woman was perfectly well." (*Med. Chir. Trans.* Vol. V.) The operation is represented as free from any particular difficulty; and it is said, that not an ounce of blood was lost. The ureter was easily avoided, which followed the peritonæum, when this membrane was pushed inwards.

A second example of the performance of the same operation is recorded in the 38th volume of the *Medical and Physical Journal*, p. 267. The operator was Mr Atkinson of York, the disease a gluteal aneurism, and the patient a stout bargeman, aged 29. This case, however, had not a fortunate result, as the patient sunk partly from the discharge, and partly from hemorrhage, about nineteen days after the operation. That the internal iliac artery was really tied, seems verified not only by the effect of the ligature upon the swelling, but by the still more positive evidence obtained by the examination of the body after death.

The possibility of tying the carotid artery in cases of wounds and aneurisms, without any injurious effect upon the functions of the brain, has been of late years repeatedly illustrated. Hebenstreit, in Vol. IV. p. 266, 3d ed. of his *Translation of* Mr B. Bell's *Surgery*, reports an instance in which the carotid artery happened to be wounded in the extirpation of a scirrhous tumour; and the hemorrhage would have been fatal, had not the surgeon immediately tied the trunk of the vessel. The patient lived many years afterwards. This is probably the earliest authentic case, in which a ligature was applied to the carotid artery. Mr Abernethy's case is perhaps the second, and that in which Mr Fleming, a naval surgeon, tied the common carotid in a sailor, who attempted suicide, and who was saved by the operation, is still later, not having occurred till the year 1803. (See *Med. Chir. Jour.* Vol. III.)

These were all cases of wounds. Sir Astley Cooper first tied the carotid artery for the cure of an aneurism in the year 1805. An incision, two inches in length, was made at the inner edge of the sterno-cleido-mastoideus from the lower part of the tumour to the clavicle. This wound exposed the omo-hyoideus and sterno-hyoideus muscles, which were drawn aside towards the trachea, and the jugular vein presented itself. The motion of this vein produced the only difficulty in the operation, as in the different states of breathing the vessel sometimes became tense and distended under the knife, and then suddenly collapsed. This vessel was kept out of the way of the knife by the finger, and the carotid artery having been exposed by another cut, two ligatures were passed under it with a common aneurism-needle. Care was taken to exclude the recurrent nerve, on the one hand, and the par vagum on the other. The ligatures were then tied about half an inch asunder; but the intervening portion of artery was left undivided. This case had not a favourable termination; and Sir Astley Cooper concludes his account of it with expressing his belief that, in future, the causes of failure may be avoided by operating before the tumour is of such size as to make pressure upon important parts; or, if the swelling is large, by letting out its contents as soon as inflammation invades it. (*Med. Chir. Trans.* Vol. I.)

In another case of carotid aneurism, operated upon by the same surgeon in 1808, success was complete. The patient was a man aged 50, and the aneurism was attended with severe pain all over one side of the head, throbbing in the brain, hoarseness, cough, slight difficulty of breathing, nausea, giddiness, &c. The patient perfectly recovered, and resumed his occupation as a porter. The intellects remained perfect; the nervous system was unaffected; and the severe pain which, before the operation, used to affect the side of the head adjoining the aneurism, never returned. In this example, two ligatures were applied, and the intervening portion of the artery divided: subsequent cases, however, have fully evinced the sufficiency of a single ligature, and the inutility of applying two, and cutting through the vessel between them.

The carotid artery has also been several times taken up with the view of checking the progress of the disease well known to surgeons under the name of aneurism by anastomosis. Of course, the complaint must be so situated as to afford a rational chance of such application of the ligature being capable of cutting off the main supply of blood to the tumour, to justify the practice. A very encouraging case is recorded by Mr Travers, who, by means of the operation, effectually cured an aneurism by anastomosis in the orbit. (*Med. Chir. Trans.* Vol. II.) And another very interesting case of the same kind has been published by Mr Dalrymple of Norwich, in the 6th volume of those *Transactions.* These examples, however, should not lead surgeons to be too confident of being always able to cure aneurisms by anastomosis on the above principle; namely, that of tying the main artery, from which the swelling receives its supply of blood. The great cause of failure is the impossibility of preventing, in some situations, the transmission of a considerable quantity of blood into the tumour, through anastomosing vessels. For cases proving the caution, with which the prognosis should be made in attempts of this kind, see one published by Mr Wardrop in the *Med. Chir. Trans.* Vol. IX. p. 206; and another detailed by Breschet, in his translation of Mr Hodgson's work *On the Diseases of Arteries*, T. II. p. 296.

The carotid artery was tied by Mr Goodlad of Bury, in Lancashire, previously to the removal of a large tumour from the side of the neck, involving the parotid gland; this proceeding was adopted with the view of diminishing the danger of hemorrhage. (See *Med. Chir. Trans.* Vol. VII.)

There are two methods of operating for the cure of axillary aneurisms; in one, the axillary artery is taken up by cutting below the clavicle; in the other, the necessary wound is made above that bone, and the subclavian artery secured at the point where it emerges from behind the anterior scalenus muscle.

Mr Hodgson recommends the first mode to be performed in the following way: A semilunar incision through the integuments, with its convexity downwards, is to begin about an inch from the sternal

end of the clavicle, and to be continued towards the acromion to the extent of three or four inches, so as to terminate near the anterior margin of the delotid muscle, without reaching into the space between the deltoid and pectoral muscle, in order to avoid wounding the cephalic vein. This incision will expose the fibres of the pectoral muscle, which are now to be divided in the direction and extent of the external wound. The flap is then to be raised by dividing the loose cellular membrane, which connects the pectoral muscle to the parts underneath it. The pectoralis minor will now be seen crossing the inferior part of the wound, and the surgeon, by introducing his finger between the upper edge of this muscle and the clavicle, may feel the pulsations of the axillary artery. Here one of the cervical nerves lies above, but in contact with the artery; the other nerves are behind it. In the dead subject the axillary vein is situated below it, but in the living the vein is distended, and conceals the artery. The cellular membrane connecting these parts is to be separated by careful dissection, or by lacerating it with a blunt instrument; then a ligature having been drawn under the artery with an aneurism-needle, the ends of the cord are to be raised, and a finger passed down, so as to compress the part surrounded by the ligature. If the artery be included, the pulsation in the aneurism will immediately cease. This precaution is highly necessary, lest one of the cervical nerves should be tied instead of the artery. The axillary artery has been tied with success below the clavicle by the late Mr Keate (see *Med. Review*, 1801), Mr Chamberlaine (*Med. Chir. Trans*. Vol. VI. p. 128), and others.

The subclavian artery may be tied at the place where it comes from behind the anterior scalenus muscle, and this plan indeed is necessary whenever the aneurismal swelling extends beyond a certain distance towards the neck. It is observed by Mr Hodgson, that, when the subclavian artery has emerged from behind the anterior scalenus muscle, it passes obliquely over the flat surface of the first rib, with which it is in immediate contact. The cervical nerves are situated above, and a little behind, the artery; the subclavian vein passes before it, and underneath the clavicle. If the finger be passed down the acromial margin of the anterior scalenus muscle, the artery will be found in the angle formed by the origin of that muscle from the first rib. The shoulder being drawn down as much as possible, the skin is to be divided immediately above the clavicle, from the external margin of the clavicular portion of the mastoid muscle, to the margin of the clavicular insertion of the trapezius. No advantage whatever is gained by cutting the clavicular attachment of the mastoid; the exposed fibres of the platysma myoides are then to be divided, the utmost care being taken not to wound the external jugular vein, which lies immediately under them, near the middle of the incision; the fibres should be detached and drawn towards the shoulder with a blunt hook. The cellular membrane in the middle of the incision is then to be cut, or separated with the finger, until the surgeon arrives at the acromial edge of the anterior scalenus muscle. His finger is then to be passed down its margin, until it reaches the part where it arises from the first rib; and in the angle formed by the origin of the muscle from the rib, the artery will be felt. The ligature is now to be conveyed under the vessel, either by means of an instrument, constructed on the principle of Desault's *aiguille à ressort* (see his *Works* by Bichât); or of the still better one lately invented by Mr Weiss, surgical instrument-maker, London.

As the difficulty of several operations for aneurisms chiefly consists in getting a ligature under the deeply situated artery, in consequence of the very little room afforded for turning the common aneurismal-needle; and even when the ligature is thus far introduced, an equal difficulty presents itself when the thread requires to be extricated from the eye of the needle; the ingenious instrument made by Weiss, and found completely to answer in practice by Sir Astley Cooper, Mr Travers, and Mr Brodie, deserves on every account to be made known to, and procured by, all operating surgeons. A particular description of it, illustrated by an engraving, may be seen in the *Edinburgh Medical and Surgical Journal*, No. LXXVI. p. 492.

Though the operation of taking up the subclavian artery at the point where it emerges from behind the anterior scalenus muscle, has now been very frequently performed, we believe only two successful cases are upon record; and these were operated upon by Dr Post of New York (see *Med. Chir. Trans*. Vol. IX.) and by Mr Liston of Edinburgh. (See *Edinb. Med. and Surg. Journ*., No. LXIV.) In some instances, the want of contrivances calculated to pass the ligature under the deeply seated artery, when the clavicle was much raised by the swelling, has prevented the completion of the operation; which unpleasant circumstance, it is to be hoped, will never happen again; the instrument constructed by Mr Weiss removing every difficulty of this kind. It should also be a maxim amongst surgeons always to recommend the operation before the swelling has attained a very large size, by which the operation is rendered more complicated, and the chances of recovery seriously lessened.

In America the arteria innominata has been lately tied by Dr Mott of New York, and in Germany by Professor Graefe of Berlin. The proposal was made several years ago in this country, but was never put in execution; owing to the common belief that such an operation would be almost necessarily fatal of itself, either from the inflammation likely to be excited by it in the neighbouring important organs; or from the danger of hemorrhage, in consequence of the adhesion of the vessel being exposed to be broken by the force of the circulation. In the case operated upon by Dr Mott, two incisions were made, one in the direction of the clavicle, and the other along the mastoid muscle. The carotid was laid bare, and traced towards the subclavian, which was found so diseased, that the only alternative left was to tie the arteria innominata. The incisions were accordingly carried more deeply, and Dr Mott having separated the recurrent and phrenic nerves, arrived at the division of the artery, and with a curved needle, passed the ligature above half an inch from this point. The

wound was then closed with a suture. In the operation, a branch of the internal mammary artery, and two of the inferior and superior thyroid, were divided, but not more than three ounces of blood were lost, and the operation was completed in about an hour. It is said, that the patient immediately after it felt quite well; his pulse was 69; the temperature of the right arm was nearly the same as that of the left; and the breathing was undisturbed. Until the 22d day after the operation, he continued to improve; the suppuration went on favourably, the ligatures came away without accident, and the pulse, which, at one time, had risen to 120, was reduced by venesection to its natural standard; the cough was disappearing, cicatrization was going on properly, and the swelling diminishing. He was now in high spirits, and so far recovered, that he walked daily in the garden of the hospital. All on a sudden, however, on the 24th day, hemorrhage from the wound took place, and though it was soon stopped, and little blood was lost, it recurred twice the next two days, difficulty of breathing came on, and the patient died on the 26th day.

Upon dissection, no mark of inflammation was traced in the arch of the aorta, the origin of the arteria innominata, or the lungs. The inner coat of the arteria innominata is described as being sound, smooth, and soft, but the parietes of the vessel were so thick, that it would scarcely admit a crow-quill. It is to be regretted that various interesting particulars, relating to the state of the tied portion of the artery, are omitted in the history.

A similar operation was performed by Graefe at Berlin on the 5th of March 1822. The patient was laid upon his back, with his head hanging down over one side of the table. A longitudinal incision was made near the front edge of the mastoid muscle, down to the sternum. The carotid artery was thus exposed, and its course followed to the point, at which it unites with the subclavian, so as to form the trunk of the arteria innominata. When the latter vessel had been distinctly exposed, a ligature was passed round it with a bent needle, and then tied. No alarming symptoms followed the operation, and the ligature came away in about a fortnight. Some time afterwards, however, a considerable bleeding arose, which was stopped by means of cold water and pressure. The patient then complained of pain in the tumour, and as a fluctuation could be plainly felt, Graefe was led to make an incision into the aneurismal sac. A large quantity of pus and grumous blood was thus discharged, and matter continued to be discharged daily from this opening, while the other granulated in the most favourable manner. The patient became feverish, however, spit blood, and died on the 68th day. Upon dissection, the lungs were found diseased. In the arteria innominata, a clot had been formed, extending from the origin of the vessel to the place where the ligature had been applied. When an injection was thrown into the aorta, the wax completely filled the arteries of the right arm, and right side of the head, proving that the circulation in these parts had been fully re-established by means of the anastomosing vessels.

As a conclusion to the remarks here introduced upon the subject of aneurism, we deem it right to notice the memorable case, in which Sir Astley Cooper tied the aorta itself. He had often placed ligatures round the aorta in dogs, and found, that the blood was readily conveyed by the anastomoses into their posterior extremities. (*Med. Chir. Trans.* Vol. II. p. 158.) The case, in which he judged it warrantable to make the experiment of tying the aorta in the human subject, was one of inguinal aneurism, on the left side, reaching so far upwards, that no operation was practicable without opening the peritonæum; and, at length, notwithstanding the trial of every means that could be thought of to check the disease, the tumour burst, and the patient was on the brink of the grave. In short, he was so reduced by repeated hemorrhages, that his feces passed involuntarily, and immediate death was only prevented by keeping up pressure upon the opening. In these desperate circumstances, Sir Astley Cooper made a small incision into the sac, above Poupart's ligament, and introducing his finger, tried if it were practicable to pass a ligature round the external iliac artery, within the cavity; but the thing was found impossible, as, instead of the vessel, "only a chaos of broken coagula" could be perceived. At the moment of withdrawing the finger, two students compressed the aorta against the spine, and the incision was then closed with a dossil of lint. It was now determined to apply a ligature to the aorta itself. An incision, three inches in length, was made in the direction of the linea alba, but slightly curved towards the left, so that the navel, which was in the centre of it, might be avoided. After the linea alba itself had been divided, a small aperture was made in the peritonæum, and the end of a finger introduced. This opening was now enlarged with a probe-pointed bistoury to nearly the same extent as the outer wound. Neither the omentum nor the intestines protruded; and during the progress of the operation, only one small convolution projected beyond the wound. With his finger-nail, the operator now scratched through the peritonæum on the left side of the aorta, and then conducting it between the aorta and the spine, he again penetrated the peritonæum on the right side of the aorta. A blunt aneurism-needle, armed with a single ligature, was next conveyed under that vessel, and tied, with the precaution of excluding the intestines from the noose. The wound was then closed by means of the quilled suture and adhesive plaster. During the operation, the feces were discharged involuntarily, and the pulse for an hour after the operation was 144. An opiate was given, and the involuntary passage of feces soon ceased. The sensibility of the right leg was very imperfect. In the night, the patient complained of heat in the abdomen; but no pain was felt on pressure being made upon it; and the lower extremities, which had been cold a little while after the operation, were now regaining their warmth, though their sensibility was very indistinct. At six o'clock, the following morning, the sensibility of the limb still continued imperfect; but, at eight o'clock, the right one was warmer than the left, and its sensibility beginning to return. At noon, the temperature of the right limb was ninety-four, and that of the left, or aneuris-

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mal one, eighty-seven and a half. At eight o'clock on the second morning after the operation, the aneurismal limb appeared livid and cold, more particularly round the aneurism; but the right leg was warm; and between one and two o'clock of the same day, after a great deal of vomiting, involuntary discharge of the urine and feces, pain in the abdomen and loins, cold sweats, &c. the patient died. In the examination of the body, not the least appearance of peritonæal inflammation was found, except at the edges of the wound; and the omentum and intestines were of their natural colour. The ligature, which included no portion of intestine or omentum, was placed round the aorta, about three quarters of an inch above its bifurcation. When the vessel was opened, a clot, of more than an inch in extent, filled it above the ligature; and below the bifurcation, another clot, an inch in extent, occupied the right iliac artery, while the left contained a third, which extended as far as the aneurism. As there were no appearances of inflammation of the viscera, Sir Astley Cooper refers the cause of death to the want of circulation in the aneurismal limb, which never recovered its natural heat, nor any degree of sensibility, though the right limb was not hindered from doing so: and he believes, that, in order to have any chance of success in a similar case, the ligature must be applied before the swelling is very large. Here, however, some doubts may be entertained concerning the propriety and necessity of such an operation: indeed, even in the desperate circumstances of the above mentioned patient, there are many good surgeons, who consider, that it would have been better to have suffered him to meet his fate in tranquillity. Be this as it may, the case is highly interesting, both in a physiological and a surgical point of view, as proving, by what took place in the limb of the sound side, that where no other impediments exist, the circulation will continue in the lower extremities, though the abdominal aorta be *suddenly* tied, or obstructed. Obliterations of portions of this vessel by disease happen gradually, and though several instances of this kind upon record, also prove the possibility of the continuance of the circulation, notwithstanding the obstruction, they do not inform us, what would be the result of a stoppage suddenly made to the course of the blood, through such a vessel as the aorta. The particulars to be gathered from the preceding case, respecting the effects of this kind of change, cannot fail to interest the studious observer of the phenomena of the animal economy.

Of Varicose Veins.

Following the subjects in the order in which they are arranged in the Article, in the *Encyclopædia,* we next find that of varicose veins; a disease sometimes very annoying and difficult to cure. The practice of tying veins for the cure of varices was well known to Pare and Dionis, who have correctly described the operation of tying and dividing the vein between the two ligatures. In modern times, Sir Everard Home has related many cases of varicose veins of the leg; some of them accompanied with tedious ulcers, which, after the vena saphena major had been tied, where it passes over the inside of the knee, were readily healed, and the dilatations of the veins relieved. There cannot be a doubt that such practice frequently succeeded; but it is quite as certain that it had many failures. Amongst other evils, an inflammation of the tied vein has been observed, extending very far in the vessel, and succeeded by great constitutional disorder, symptoms very analogous to those of typhus fever and rapid dissolution. In some of these cases, previously to their termination, abscesses form in the direction of the vessel below or above the ligature; while, in other examples, such collections of matter are not observed.* In short, the dangers arising from an inflammation of the internal coat of the veins form the most serious objection to the old manner of operating for the cure of varices. The occasional subsequent attack of this membrane by inflammation, followed by a fever of a very serious nature, rendered several judicious surgeons doubtful of the propriety of continuing the practice. Certain reflections, however, induced Mr Brodie to suspect, that the same ill effects would not follow a similar operation upon the branches themselves. He remarks, that "where the whole of the veins of the leg are in a state of morbid dilatation, and the distress produced by the disease is not referred to any particular part, there seem to be no reasonable expectations of benefit, except from the uniform pressure of a well-applied bandage. But, not unfrequently, we find an ulcer which is irritable and difficult to heal, on account of its connection with some varicose vessels; or, without being accompanied by an ulcer, there is a varix in one part of the leg, painful, and perhaps liable to bleed, while the veins in other parts are nearly in a natural state, or, at any rate, are not the source of particular uneasiness. In some of these cases (says this gentleman), I formerly applied the caustic potash, so as to make a slough of the skin and veins beneath it; but I found the relief, which the patient experienced from the cure of the varix, afforded but an inadequate compensation for the pain to which he was subjected by the use of the caustic, and the inconvenience arising from the tedious healing of the ulcer, &c.

"In other cases, I made an incision with a scalpel through the varix, and the skin over it. This destroyed the varix as completely as it was destroyed by the caustic; and I found it to be preferable to the use of the caustic, as the operation occasioned less pain, and in consequence of there being no loss of substance, the wound was cicatrized in a much shorter space of time." Mr Brodie employed this method with advantage in several instances; but he afterwards improved and simplified it as follows: "It is evident (says he) that the extensive division of the skin over a varix can be attended with no advantage. On the contrary, there must be a disadvantage in it,

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* See Travers *On Wounds and Ligatures of Veins, Surgical Essays,* Part I.; Oldknow, in *Edin. Med. and Surg. Jour.* Vol. V.; R. Carmichael, in *Transactions of the King's and Queen's College of Physicians,* Vol. II.

as a certain time will necessarily be required for the cicatrization of the external wound. The improvement consists in this: the varicose vessels are completely divided, while the skin over them is preserved entire, with the exception of a moderate puncture, which is necessary for the introduction of the instrument, with which the incision of the veins is effected." For this operation, Mr Brodie has generally employed a narrow sharp-pointed bistoury, slightly curved, with its cutting edge on the convex side. Having ascertained the precise situation of the vein, or cluster of veins, from which the distress of the patient appears principally to arise, he introduces the point of the bistoury through the skin, on one side of the varix, and passes it on between the skin and the vein, with one of the flat surfaces turned forwards, and the other backwards, until it reaches the opposite side. He then turns the cutting edge of the bistoury backwards, and in withdrawing the instrument the division of the varix is effected. The patient is to be kept quiet in bed for four or five days after the operation, and the bandage and other dressings removed with the utmost care and gentleness. In none of the cases in which Mr Brodie had operated at the time, when he published an account of the plan, had the operation been followed by inflammation of the coats of the divided veins. The examples, for which the method is considered by him advisable, are not those in which the veins of the leg generally are varicose, or in which the patient has little or no inconvenience from the complaint; but those in which there is considerable pain referred to a particular varix; or in which hemorrhage is liable to take place from the giving way of the dilated vessels; or in which they occasion an irritable and obstinate varicose ulcer. (*Med. Chir. Trans.* Vol. VII.)

Of Amputation.

Many useful additions might be made to what is stated concerning amputation, in the former Article; but we must confine our remarks to a few of the most interesting things, on which the genius and industry of modern surgeons have been beneficially exerted in this part of practice. Every person accustomed to see much of surgery knows very well, that it is frequently a matter of greater difficulty to understand precisely when amputation ought, or ought not to be performed, than how the operation is to be done; and certainly a more important question, with reference to the patient's safety, and his future crippled or unmutilated condition, cannot be imagined.

Compound fractures of the thigh from gunshot violence are injuries, in which the prompt performance of amputation is frequently the only chance of preserving life. However, in these examples, the urgency for the operation varies. According to Schmucker, all gunshot fractures of the middle and upper part of the femur are attended with very great danger. But, says he, if the fracture be situated at the lowest part of the bone, the risk is considerably less, the muscles here not being so powerful. In such a case, therefore, amputation should not be performed before every other means has been fairly tried; and very frequently he treated fractures of this kind with success, though the limb sometimes continued stiff. Of course, these remarks imply, that, in addition to the mere solution of continuity in the bone, the soft parts are not extensively contused and lacerated, nor the bone very much smashed; circumstances which, as far as our experience in military surgery extends, would form a just reason against any attempt to save the limb; as the delay would neither be attended with success, nor leave a second opportunity of amputating with an equal chance of rescuing the patient from danger. When the bone was completely fractured, or splintered by a ball at its middle, or above that point, Schmucker, very judiciously, never waited for the bad symptoms to commence, but amputated before they had had time to originate; and, when the operation was done early enough, most of his patients were saved. On the contrary, when the operation had been delayed some days, and inflammation, swelling, and fever had come on, the issue was much less fortunate. The correctness of the opinion of this experienced surgeon is confirmed by the valuable testimony of our army surgeons, who had opportunities, in the course of the late war, of seeing many of those severe gunshot injuries of the thigh. In particular, the following observations upon the point under consideration, delivered by Mr Guthrie in his *Treatise on Gunshot Wounds*, are entitled to the greatest attention. "The danger and difficulty of cure, attendant on fractures of the femur from gunshot wounds," says he, "depend much on the part of the bone injured, and, in the consideration of these circumstances, it will be useful to divide it into five parts. Of these, the head and neck, included in the capsular ligament, may be considered the first; the body of the bone, which may be divided into three parts; and the spongy portion of the lower end of the bone, exterior to the capsular ligament, forming the fifth part. Of these, the fractures of the first kind are, I believe, always ultimately fatal, although life may be prolonged for some time. The upper third of the body of the bone, if badly fractured, generally causes death at the end of six or eight weeks of acute suffering.* I have seen few escape, and then not with an useful limb, that had been badly fractured in the middle part Fractures of the lower or fifth division are in the next degree dangerous, as they generally affect the joint; and the least dangerous are fractures of the lower third of the body of the bone." With respect even to these, Mr Guthrie also admits, that, when there is much shattered bone, the danger is great; so that a thigh fractured by gunshot, even without particular injury of the soft parts, is one of the most dangerous kinds of wounds that ever occur

The very important maxim in military surgery is now completely settled by the general assent of every experienced army surgeon, namely, that, when a limb is so injured as to leave no rational chance of ultimately preserving it, amputation should be performed without delay, before inflammation, fever, and other bad symptoms originate. This rule is parti-

* None of the cases of this kind which fell under our own observation lasted so long.

cularly applicable to the cases of compound fracture of the femur above specified as requiring the operation.

Another kind of injury, urgently demanding the immediate performance of amputation, is that in which a considerable portion of the whole thickness of a limb has been carried away by a cannon-ball or bomb. The necessity of this practice was inculcated by M. Faure himself, in former days one of the chief opponents of operating in the early stage of gunshot injuries; and it is strongly insisted upon in the valuable writings of Schmucker, Larrey, &c.

When a body, propelled by the explosion of gunpowder, strikes a limb so as to smash the bones, and violently contuse, lacerate, and deeply tear away the soft parts, amputation ought not to be delayed. If the operation be put off, all the injured parts will soon be attacked with gangrene, and the constitution be so generally and severely disordered, that a second opportunity of removing the limb will hardly be afforded. It is but justice to the memory of Mr Faure to mention, that this was a kind of case, which he particularly pointed out, as requiring the operation without the least delay.

If a similar body were to carry away a great mass of the soft parts, and the principal vessels of a limb, without fracturing the bone, immediate amputation is proper. Mr Guthrie also lays it down as a rule, to operate without loss of time, when the artery and vein on the inside of the thigh are injured, even though there should be no fracture. This gentleman likewise approves of the same practice, when a wound of the femoral artery accompanies a fracture of the thigh-bone.

Another case, demanding the immediate performance of amputation, is where a grape-shot has struck the thick part of a limb, broken the bone, divided and torn the muscles, and destroyed the principal nerves, without interfering, however, with the main artery. Mr Guthrie says, that if a cannon-shot strike the back part of the thigh, and carry away the muscular part behind, and with it the sciatic nerve, amputation is necessary, even though the bone be unhurt. In this case, he would not make a circular incision, but save a flap from the fore part, or sides, to cover the bone.

If a spent cannon-ball, or one that has been reflected, should strike a limb obliquely, without producing a solution of continuity in the skin, as often happens, the parts which resist its action, such as the bones, muscles, tendons, aponeuroses, and vessels, may be crushed and lacerated. Here, if the bones should feel through the soft parts as if they were smashed, and a kind of fluctuation indicate the rupture of the large vessels, amputation should take place without delay. The real state of the parts under the skin, however, should first be examined by means of an incision, which, when the principal vessels and the bones have escaped injury, will be of itself adequate to afford relief, by letting out the large quantity of extravasated blood generally found in such cases under the integuments.

When the articular heads of the bones are much broken, especially those which form the joints of the knee or foot, and the ligaments are lacerated, immediate amputation is the right practice. Fractures of the patella, without injury of the other bones, will sometimes admit of delay. Even extensive sword wounds of the elbow joint are alleged by Baron Larrey to demand immediate amputation.

The common doctrine in the treatment of mortification has always been, not to attempt amputation until the stoppage of the disorder is denoted by the appearance of a red line on the margin of the living skin. However, the observations of Baron Larrey tend to prove that this maxim, if acted upon in cases of mortification from gunshot wounds and external injuries, would be productive of the worst consequences, and leave the patient hardly a possibility of recovery. On the contrary, he strongly urges the speedy performance of the operation, even though the mortification be yet in a spreading state. It was formerly imagined that the stump would always be attacked with gangrene, if amputation were done under these circumstances; but modern experience contradicts this opinion, and some observations, made by Mr Lawrence on this point, will be found to corroborate the view of the subject given by Larrey. (*Med. Chir. Trans.* Vol. VI.)

The establishment of the propriety of the severe operation of amputation at the hip-joint; the determination of the circumstances under which this attempt to save the patient should be made; and the settlement of the best manner of performing the operation, are also some of the useful results of the attention and zeal, with which the practice of surgery has been cultivated in modern times. As there are unquestionably some descriptions of injury where life must inevitably be lost if this proceeding be rejected, and experience proves that it sometimes answers, an important consideration is, What cases are most proper for it? Here we fully agree with Dr Thomson, that the examples in which it is particularly called for, and where no delay should be suffered, are those in which the head or neck of the thigh-bone has been fractured by a musket-ball, grape-shot, or small piece of shell. Larrey thinks the operation proper where the thigh has been shot off high up, or where the femur and soft parts near the hip have been broken and extensively lacerated by a cannon-ball or shell. Under such circumstances, however, the operation, though perhaps the only chance, must almost always fail, because injuries of this description occasion a shock to the constitution, of which the patient mostly sinks either immediately or in a few hours. There have now been at least three successful amputations at the hip-joint; the first was done by Larrey, the second by Mr Brownrigg, and the third by Mr Guthrie. All the examples were gunshot injuries, the only cases, we believe, in which the operation is ever justifiable. For further observations on this subject, the reader may consult Cooper's *Dictionary of Surgery*, where will be found a description of the various methods of operating, and a detail of the reasons for or against all the different modes which have been proposed.

Amputations, in general, have been of late years much improved by the rejection of the large clumsy ligatures, which were formerly used; whereby considerable irritation was kept up, union by the first

intention materially prevented, the formation of large abscesses promoted, and secondary hemorrhage rendered much more frequent, than at the present time. Mr Lawrence adopts the plan of tying the vessels with fine silk ligatures, and cutting off the ends as close to the knot as is consistent with its security. Thus the extraneous matter in the wound is reduced to the insignificant quantity, which forms the noose actually surrounding the vessel, and the knot by which that noose is fastened. Of the silk which he commonly employs, a portion, sufficient to tie a large artery, when the ends are cut off, weighs between $\frac{1}{30}$ and $\frac{1}{60}$ of a grain; a similar portion of the thickest kind weighs $\frac{1}{20}$ of a grain, and of the slenderest $\frac{1}{80}$.

Mr Lawrence observes, that the kind of silk twist, which is commonly known in the shops by the name of dentists' silk, and which is used in making fishing lines, is the strongest material, in proportion to its size, and, therefore, the best calculated for the purpose, which requires considerable force in drawing the thread tight enough to divide the fibrous and internal coats of the arteries. This twist is rendered very hard and stiff by means of gum, which may be removed by boiling it in soap and water; but the twist then loses a part of its strength. The stoutest twist which Lawrence uses is a very small thread, compared with ligatures made of inkle. The quantity of such a thread necessary for the noose and knot on the iliac artery weighs $\frac{1}{20}$ of a grain; or, if the gum has been removed, about $\frac{1}{26}$. This gentleman's experience fully proves, that there is no danger of these ligatures cutting completely through the vessel, as certain surgeons have apprehended. Some objections have been urged against the practice, on the ground of its giving rise occasionally to little festerings, and even to ill-looking abscesses; but, it is justly remarked by Mr Lawrence, in reply to these objections, that as they are not accompanied by any description of the materials, or size of the ligature, nor by any details of the unfavourable cases, we cannot judge whether the events alluded to are to be attributed to the method itself, or to the way in which it was executed. (*Med. Chir. Trans.* Vol. VI.) In a paper of later date, he says, his further experience has confirmed the usefulness of the method; that, by diminishing irritation and inflammation, and simplifying the process of dressing, it very materially promotes the comfort of the patient and the convenience of the surgeon; while it has not produced ill consequences, or any unpleasant effect in the cases which have come under his own observation. The small knots of silk generally separate early, and come away with the discharge; where the integuments have united by the first intention, the ligatures often come out rather later with very trifling suppuration, and, in some instances, they remain quietly in the part. (*Op. cit.* Vol. VIII.)

Of Syphilis.

In relation to syphilis, the judicious and impartial investigations of modern surgeons have succeeded in dispelling a considerable number of erroneous doctrines formerly entertained respecting this intricate and perplexing disease. Amongst other things, Mr Hunter inculcated, that "the venereal matter, when taken into the constitution, produces an irritation, which is capable of being continued, independent of the continuance of absorption, and the constitution has no power of relief; therefore, a lues venerea continues to increase." The same criterion was proposed by Mr Abernethy, who states, that the "constitutional symptoms of the venereal disease are generally progressive, and never disappear, unless medicine be employed." And, notwithstanding some dissent may be traced in both old and recent writers, from the belief that mercury was absolutely essential to the cure of syphilis, and an opposite conclusion might easily have been made from a review of the whole history of the subject, including the practice of former and present times; still the contrary hypothesis was what was always taught in all the great medical schools of this country, even till within the last few years. But this mistaken notion no longer prevails; and no facts are more completely established, than that mercury, however useful it may frequently be in the treatment of this disease, is not absolutely necessary for the cure either of the primary or secondary symptoms; and that the disease, so far from always growing worse, unless mercury be administered, ultimately gets well of itself, without the aid of this or any other medicine. If any man yet doubt the general truth of this statement, let him impartially consider the many facts and arguments brought forward in proof of it, in the writings of Dr Fergusson, Dr Hennen, Dr Thomson, Mr Rose, Mr Guthrie, Mr Bacot, and others. In short, if there be such a sceptic now living in this country, let him peruse the returns made by the surgeons of the whole British army; let him consider the evidence of the surgeons of other countries, especially that of Cullerier, who annually demonstrates to his class of pupils the cure of venereal ulcers without mercury; and the testimony and practice of the German surgeons, who were attached, during the war, to regiments of their countrymen in the British service. The fact is, therefore, indisputable, that the venereal disease, in all its ordinary and diversified forms, is capable of a spontaneous cure; and, consequently, that the question, whether a disease is syphilitic or not, can never be determined by the circumstance of the complaint yielding, and being permanently cured, without the aid of mercury. Yet, as Mr Rose has observed, the supposition that syphilis did not admit of a natural cure, and that mercury was the only remedy that had the power of destroying its virus, was of late so much relied upon, that, where a disease had been cured without the use of that medicine, and did not afterwards return,—such fact alone, whatever might have been the symptoms, was regarded as sufficient proof, that it was not a case of syphilis. And, as the same writer very judiciously remarks, the refutation of these notions is of considerable importance, "not so much in reference to the treatment of syphilis, under common circumstances (for the strikingly good effects of mercury will probably not render it advisable, in general, to give up the use of that remedy"), as to the change it will produce in our views of the diagnosis of the disease. The distinction, which has engaged such a share of attention of late years, and which is evidently so important be-

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tween syphilis and syphiloid diseases, has been made to depend so much on the former admitting of no cure, except by mercury, that, if this principle should be found to be erroneous, the difficulties which have attended it will be in a great measure explained. (*Med. Chir. Trans.* Vol. VIII.)

Dr Fergusson assures us that, in Portugal, the disease, in its primary state amongst the natives, is curable without mercury, by simple topical treatment; that the antisyphilitic woods, combined with sudorifics, are an adequate remedy for constitutional symptoms; and that the virulence of the disease has there been so much mitigated, that, after running a certain course (commonly a wild one) through the respective orders of parts, according to the known laws of its progress, it exhausts itself, and ceases spontaneously. (*Op. cit.* Vol. IV.) The conclusion to which the writings of Mr Pearson led, long before recent investigations began, was, that venereal sores might be benefited, and even healed, under the use of several inert insignificant medicines. But, amongst modern writers, we find Dr Clutterbuck one of the earliest in distinctly asserting, that the healing of a sore without mercury was no test of its not being venereal. (*Remarks on the Opinions of the late J. Hunter*, 1799.) It is curious to remark, that this important truth is rendered conspicuous in the treatises of Mr Pearson and Dr Clutterbuck, though both these gentlemen were, at the time of their publishing, as much advocates for full mercurial courses as can well be conceived. But, although the whole history of syphilis, and of the effects of various articles of the materia medica, if carefully reflected upon, must have led to the abovementioned inference; the truth was never placed in such a view as to command the general belief of all the most experienced surgeons in this and other countries of Europe. It is not meant, that the truth was not seen and remarked by several of the older writers; for that it was so any man may convince himself by referring to their works. But it is to be understood, that a great deal of indecision could never be renounced as long as prejudices interfered with the only rational plan of bringing the question to a final settlement; we mean that of instituting experiments upon a large and impartial scale, open to the observation of numerous judges, yet, under such control, as insured the rigorous trial of the non-mercurial treatment. Nor could such investigation be so well made by any class of practitioners as the army surgeons, whose patients are numerous, and obliged to follow strictly the treatment prescribed, without any power of going from hospital to hospital, or from one surgeon to another, as caprice may dictate; or of eluding the observation of the medical attendants after a seeming recovery. To us it appears, that the most important and cautious document yet extant, on the two questions of the *possibility* and *expediency* of curing the venereal disease without mercury, is the paper of Mr Rose. For, let it not be assumed, that, because the army surgeons find the venereal disease curable without mercury, they mean to recommend the total abandonment of that remedy for the distemper, any more than they would argue that *possibility* and *expediency* are synonymous terms. At the time when Mr Rose published his observations, he had tried the non-mercurial treatment in the Coldstream Regiment of Guards, during a year and three quarters, and had thus succeeded in curing all the ulcers on the parts of generation which he met with in that period, together with the constitutional symptoms to which they gave rise. "I may not be warranted in asserting," says this gentleman, "that many of these were venereal, but, undoubtedly, a considerable number of them had all the appearances of primary sores produced by the venereal virus, and arose under circumstances where there had been at least a possibility of that virus having been applied. Admitting that there is nothing so characteristic in a chancre as to furnish incontrovertible proof of its nature, it will yet be allowed, that there are many symptoms common to such sores, although not entirely peculiar to them; and whenever these are met with, there are strong grounds to suspect, that they are the effects of the syphilitic virus. In a sore, for instance, appearing shortly after a suspicious connection, where there is loss of substance, a want of disposition to granulate, and an indurated margin and base, there is certainly a probability of that poison being present. Amongst a number of cases of such a description, taken indiscriminately, the probability of some being venereal is materially increased, and must at last approach nearly to a certainty. On this principle, some of the sores here referred to must have been venereal. They were also seen by different surgeons, on whose judgment I would rely, who agreed in considering many of them as well-marked cases of true chancre." The men thus treated were examined almost every week for a considerable time after their apparent cure, "both that the first approach of constitutional symptoms might be observed, and that any deception from an underhand use of mercury might be guarded against." In Mr Rose's practice, all idea of specific remedies was entirely laid aside. The patients were usually confined to their beds, and such local applications were employed as the appearances of the sores seemed to indicate. Aperient medicines, antimony, bark, vitriolic acid, and occasionally sarsaparilla, were administered. Upon an average, one out of every three of the sores, thus treated, was followed by some form or another of constitutional affection; this was in most instances mild, and sometimes so slight, that it would have escaped notice, if it had not been carefully sought for. The constitutional symptoms were evidently not such as could be regarded as venereal, if we give credit to the commonly received ideas on the subject. Caries of the bones, and some of the least equivocal symptoms, did not occur. In no instance was there that uniform progress, with unrelenting fury, from one order of symptoms and parts affected to another, which is considered as an essential characteristic of true syphilis. The constitutional symptoms also yielded without the aid of mercury; and frequently, primary sores, corresponding to what has been called the true chancre with indurated base, were cured in this manner; yet without being followed by any secondary symptoms. We are also

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informed, that several cases occurred of a cluster of ill-conditioned sores over the whole inner surface of the prepuce, and behind the corona glandis; and also of a circle of small irritable sores, situated on the thickened and contracted ring at the extreme margin of the prepuce. These occasionally produced buboes. None of the sores of this description were followed by any constitutional affection. Mr Rose bears testimony to the ill effects of mercury and stimulants in cases of phagedenic ulcers, and confirms an opinion, not uncommonly prevailing, that they are seldom followed by secondary symptoms; which opinion, perhaps, ought to be qualified with the condition, mentioned by Mr Guthrie (*Med. Chir. Trans.* Vol. VIII.), that no mercury be given; for, in this circumstance, secondary symptoms are more frequent.

But, although the fact of the *possibility* of curing every kind of ulcer on the genitals without mercury is now completely established, and it is of great importance with regard to the removal of an erroneous doctrine concerning the diagnosis, and also in encouraging practitioners even not to be frightened into the use of mercury, when the patient's constitution is in an unfavourable state for its exhibition, or the case is of a doubtful nature; yet, the *expediency* of the non-mercurial practice must evidently be determined by other considerations; the principal of which are, the comparative quickness of the cures effected with or without mercury; the comparative severity and frequency of secondary symptoms; and the generally acknowledged fact, that a syphilitic sore is not indicated, with any degree of certainty, by its mere external appearance, or, indeed, any other criterion. For the consideration of the evidence on these, and various other points connected with the present subject, we must refer to the last edition of Cooper's *Surgical Dictionary*, from which many of the foregoing remarks are selected.

Inflammation of the Iris.

In the former article, a short section will be found upon inflammation of the iris; a disease upon which modern surgeons have bestowed all the attention which its importance required, and the results, as might be expected, have been greater accuracy in the discrimination of the complaint, and much improvement in its treatment. The iris, next to the conjunctiva, is found to be that texture of the eye, which is most frequently affected with inflammation. It often becomes inflamed in consequence of surgical or accidental wounds of the eye-ball. A peculiar and characteristic iritis is generally supposed to be one of the constitutional effects of syphilis. Scarcely any disease, to which the eye is subject, has a more immediate or rapid tendency to destroy vision.

In the *idiopathic iritis*, as Professor Schmidt has remarked, besides the common symptoms of ophthalmy, certain changes happen at the very commencement of the case, indicating the seat of inflammation. The pupil appears contracted, the motions of the iris are less free, and the pupil loses its natural bright black colour. The brilliancy of the colour of the iris fades, and the part becomes thickened and puckered, with its inner margin turned towards the crystalline lens. The change of colour happens first in the lesser circle of the iris, which becomes of a darker hue; and afterwards in the greater circle, which turns green, if it had been greyish or blue; and reddish, if it had been brown or black. The redness accompanying these changes is by no means considerable, and is at first confined to the sclerotic coat, in which a number of very minute rose-red vessels are seen, running in straight lines towards the cornea. In the words of Mr Saunders, the vascularity of the sclerotica is very great, whilst that of the conjunctiva remains much as usual, the plexus of vessels lying within the latter tunic. The inosculations of these vessels are numerous, and at the junction of the sclerotica with the cornea, they form a kind of zone. Here the vessels disappear, not being continued over the cornea, as in a case of simple ophthalmy, but penetrating the sclerotica in order to reach the inflamed iris. The irritation of the light is distressing, and the patient is much annoyed by any pressure on the globe of the eye, or by the rapid or sudden motions of this organ. Considerable uneasiness is felt over the eyebrow, and acute lancinating pains shoot through the orbit towards the brain. The pupil loses its circular form, becomes somewhat irregular, and presents a greyish appearance. When examined with a magnifying glass, this appearance is found to be produced by a substance very like a cobweb, occupying the pupil, and which can soon afterwards be distinguished, even without the aid of a glass, to be a delicate flake of coagulable lymph, into which the dentations of the irregular margin of the iris seem to shoot, and at these points adhesions are apt to be formed. In consequence of these adhesions, the patient, whose vision has been all along indistinct, now complains of being able to see only on one side, or part of an object. Lymph is next deposited on the anterior surface of the iris, and between the iris and the capsule of the lens, and often in such quantity, that it extends through the pupil, and hangs down to the bottom of the anterior chamber. If this process is not checked, the pupil becomes entirely obliterated, or the iris adheres to the capsule of the lens; a very small opening only being left, which is usually occupied by an opaque portion of the capsule, or of organized lymph, and the patient is quite blind.

Schmidt, Beer, and many English surgeons, believe one form of iritis to be *syphilitic*. The affection of the iris may be accompanied with other symptoms of lues venerea, or it may take place singly before any of these have appeared. A pale redness, all round the cornea, is the first symptom perceived in the *syphilitic iritis*: it is at first confined to the sclerotic coat, but the conjunctiva very soon participates in it, and afterwards is the reddest of the two parts. However few the vessels may be elsewhere, there is always a broad zone of them all round the cornea. The redness is also described as having a peculiar tint, being brownish, something like the colour of cinnamon; or, as Mr Travers expresses himself, having a brick-dust, or dusky red, instead of a bright scarlet hue. The lymph, he says, is compact and brown, and intimately adherent to the iris, instead of being curd-like, loose, and

of a yellowish white colour. (*Surgical Essays*, Part I.) The whole of the cornea now grows hazy, without being at any point actually opaque. The pupil becomes contracted, and the iris limited in its motions, as in common iritis; but the pupil, instead of preserving its natural situation, is drawn in the direction upwards and inwards, towards the root of the nose, and is irregular. The iris also loses its natural colour, and projects forwards. An aggravation of the symptoms always takes place towards evening; the intolerance of light, and painful sensibility of the whole eye increasing, and a gush of tears following every change of light and temperature. At length, a regular nightly pain begins, which is extremely severe, and strictly limited to that part of the cranium which is immediately over the eye-brow. It reaches its greatest severity about midnight, and then diminishes till about four or five o'clock in the morning, when it ceases. Afterwards, one or more reddish-brown tubercles, of a spongy look, arise either on the pupillary or ciliary edge of the iris, or on both of them, and grow rather fast. Sometimes little ill-conditioned ulcers are produced on the cornea, conjunctiva, or skin of the eye-lids. Even when the case terminates in the most favourable manner, the eye remains, for a long time, peculiarly sensible to the influence of cold and moisture. In the iritis, which appears in conjunction with eruptions, supposed to be connected with the abuse of mercury, the inflammation is less active, than in the other forms of iritis. The pupil is not much contracted, and lymph is less apt to be effused.

The principal danger of iritis is ascertained to depend upon the effusion of lymph, its quick organization, the rapid formation of adhesions between the iris and other parts, and the closure and obstruction of the pupil. Now, in modern practice, the management of the disease is much more successfully effected than twenty years ago, when in truth the nature of the case was but incorrectly known; and the great thing that has led to the improved treatment is the discovery of the fact, that mercury is one of the most effectual means of stopping the effusion, and promoting the absorption of lymph in the adhesive inflammation; a fact which was first particularly insisted upon by Dr Farre.

In idiopathic iritis, before lymph is effused, the means most likely to do good are copious bleeding and cathartics, followed by nauseating doses of tartarized antimony. This plan is to be assisted with leeches applied near the eye, and repeated according to the urgency of the case. When the inflammation stops in this stage, Saunders states, that the cure may be completed by covering the eye with linen wet with a collyrium of acetite of lead, and keeping the patient for some time in a dark room. Schmidt, however, condemns all cold applications in iritis as quite useless; and he asserts, that the only admissible topical treatment consists in fomenting the eye with warm water. In the first stage of the disease, he says, blisters on the temple, or behind the ears, have little or no effect, though they are sometimes useful when put on the nape of the neck.

But no sooner is lymph effused, than the principal aim of the surgeon should be to bring about its absorption. Of all remedies for this purpose, none answer so well as mercury, which is to be freely exhibited, so as to affect the constitution as quickly as possible. The ointment, or pil. hydrargyri with opium, may be employed, and, in very urgent cases, the medicine may be used both externally and internally. In the second, or adhesive stage of iritis, Beer prescribes calomel combined with opium; applies to the eye itself a collyrium, containing oxymuriate of mercury, mucilage, and a considerable proportion of vinum opii; and, when this application ceases to be effectual, he has recourse to a salve, composed of two drachms of fresh butter, six grains of red precipitate, and eight grains of the extract of opium. Frictions over the eye-brow once a day, with mercurial ointment, containing mercury, he says, will also have great effect in producing the absorption of the effused lymph. The late Mr Saunders used to resist the tendency of the pupil to contract by means of the extract of belladonna; with which he smeared the eye-lids and eye-brows, or which he diluted with water, and then dropped between the eye and eye-lids.

In the syphilitic iritis, general bleeding is not considered so necessary as in idiopathic cases. When the pain in the eye and head is severe, leeches may be applied, and the bowels emptied. The nightly attacks of pain are to be prevented by rubbing a small quantity of mercurial ointment, with opium, just above the eye-brow, a short time before the pain is expected to begin, and then covering the eye with a folded piece of warmed linen. Mercury is to be employed so as to affect the system, either in the form of ointment, or of calomel pills joined with opium.

The form of iritis, conjectured to proceed from the abuse of mercury, or accompanying ambiguous eruptions of the papular sort, or such as are not syphilitic, also requires a combination of the depleting with the mercurial plan. This circumstance, in relation to the first of these cases, seems extraordinary, as involving the seeming inconsistency of mercury being both the exciting cause, and the antidote of the disease. But, though iritis does present itself, accompanied or connected with various suspicious symptoms, and in individuals who have used considerable quantities of mercury, it cannot be said that mercury alone, that is, without the agency of some other additional causes, is really an exciting cause of iritis; or, if such assertion be made, the clear proof of the fact is yet wanting; and here we should also be disinclined to receive, as such proof, any rare and solitary instance of an attack of iritis after the free use of mercury in a case of a totally different nature from syphilis, or syphiloid disease. Mercury cannot be supposed to render a patient insusceptible of iritis; and, therefore, a few uncommon attacks after its administration for liver complaints, or other disorders quite unconnected with lues venerea, or the many diseases resembling it and confounded with it, would prove little or nothing to the point. In the meanwhile, the good effect of mercury in the examples of iritis, *supposed* to arise from the

previous abuse of it, seems to be established; which is the information of most value to the practical surgeon.

Lastly, we shall enumerate, amongst recent inventions of great utility in practice, the bed, invented by Mr Earle, for patients with accidents and diseases requiring a state of permanent rest; also his apparatus for more effectually securing the upper extremity; an object of great consequence in fractures of the clavicle, and other injuries of the bones about the shoulder.

(T. T. T.)

Boundaries and Extent.

SURRY, an inland English county on the banks of the Thames, by which, on its northern side, it is separated from Middlesex. On the west it is bounded by Berkshire and Hampshire; on the south by Sussex; and on the east by Kent. Its shape is an oblong, of moderate regularity, except on its northern side, where considerable indentations are formed by the curvatures of the Thames. Its length, from east to west, is about thirty-seven miles; and its breadth, from north to south, about twenty-five. The area is 758 square miles, or 485,120 statute acres.

Population and Divisions.

By the census of 1821, the houses were found to be 64,790, inhabited by 88,806 *families*; of whom 14,944 were chiefly employed in agriculture; 46,811 in trade, manufactures, or handicraft; and 27,051 were comprehended in neither of those classes. The number of persons was 398,658; of whom 189,871 were males, and 208,787 females. From its vicinity to the metropolis, more than two-thirds of the inhabitants may be included in the numerical population of London. Southwark, one of the suburbs to the capital, and the hundred of Brixton, adjoining to it, contain 267,994 inhabitants; and the other portions of the county are more thinly peopled than most parts of England. The divisions are thirteen hundreds; and the boroughs of Southwark and Guilford, comprising 146 parishes; all of which are within the diocese of Winchester.

Face of the Country.

The face of the country exhibits great varieties. On the north, by the banks of the Thames, from Lambeth to Egham, the richness of the highly improved country, the abundance of trees, the verdure of the meadows, the undulation of the hills, with the numerous elegant private houses, all display the most pleasing marks of taste, wealth, and comfort. The centre of the county is a range of chalk hills, much covered with thick underwood, intermixed with arable fields badly cultivated, and utterly destitute of water. The south part, at the foot of this range of hills, is a flat clayey country, nearly impassable in the winter; but covered with some of the best and largest oak trees that are to be found in the island. The north-western part exhibits a considerable tract of the most sterile black heaths that can exist; whilst, on the south-west, near Farnham, is some of the most productive land in England.

Productions.

The productions of agriculture are various; and, at a distance from the capital, scarcely differ from those of other districts in similar circumstances. A greater proportion of clover and of sanfoin is cultivated on the hills, where there are no natural meadows, than in most other parts of the kingdom. Woad is also grown in the same districts very extensively. It is commonly sowed with turnips, which are to be fed with sheep who will not touch that plant. It is generally harvested before the corn crops are ready for the sickle. Near London, the garden ground extends over several thousand acres. The growing of plants, for the use of the druggists and perfumers, engages much attention; and those gardens supply peppermint, lavender, wormwood, chamomile, anniseed, liquorice, poppy, and other similar articles. Hops are extensively cultivated near Farnham, and are sold for higher prices than those of any other districts.

Minerals and Fossils.

There are no minerals now raised in the county; for, though iron is known to exist, and was formerly worked with charcoal, the improvements in chemistry have fixed that operation to the coal districts. The fossil riches are valuable, especially fuller's earth, which is of the best quality, and in abundance, and supplies the cloth manufacturers both in the west and north of England. Limestone is plentiful; and that, as well as chalk, is converted into lime, upon a great scale, for the use of the builders of the metropolis. The quarries of Mersham produce an excellent firestone; and the sand near Dorking and Ryegate is in great request for making glass, hour-glasses, writing, and other purposes.

Manufactures.

The manufactures are various and extensive; but, being almost exclusively near the metropolis, may more properly be considered as belonging to London than to the county of Surry. The principal of those are breweries and distilleries on a magnificent scale. The tanners, rope and sail makers, glass-makers, starch and hair-powder makers, and the preparers of vinegar and raisin wines, carry on large trades. A few miles farther from London, chiefly on the banks of the river Wandle, the calico printers and bleachers have large establishments.

Rivers, Canals, and Rail-Roads.

All the rivers of this county empty themselves into the Thames; the only navigable river, besides that fine stream which bounds it, is the Wey, on which barges pass above Guildford into the Basingstoke canal. The Mole is a beautiful small stream, celebrated for sinking into the ground, and at some few miles lower again emerging; it runs to the Thames. The Wandle is of short course, but of great value, from the vast quantity of mill machinery which it keeps in motion, and the employment it thus affords to several thousand persons. It rises in one spring near Croydon, turns a large mill within a few yards of its source, and runs nine miles before it joins the Thames. The Medway rises in Surry; but is a very small stream till it enters the county of Kent. The Loddon, a small river on the western border, is chiefly valuable for the supply of water it affords to the Basingstoke canal. That canal was one of the first executed in this part of the king-

Surry.

dom, having been finished in 1796. The Croydon canal only reaches that town from the Thames; and the little success attending it has put a stop to its being carried farther, as was originally intended. The Surry canal runs parallel to the Thames; but, by avoiding the sinuosities of that river and the whole of the metropolis, is expected to be beneficial to the inhabitants on the upper banks, by conveying coals and other heavy commodities to them, from ships, at a cheap rate. Its entrance, from the Thames below London Bridge, has a fine bason, capable of containing 100 sail of square-rigged vessels. Rail-roads have been constructed from Merstham to the Thames; but the project has not repaid the persons who have advanced the capital a sufficient interest to induce any farther attempts.

Antiquities and Interesting Objects.

Among the Roman antiquities of this county are the Ermine way, which traversed it, and the remains of which may still be traced near Dorking. The piles are still standing in the river Thames at Walton, which were placed there by the ancient Britons, to impede the passage of Julius Cæsar. The vestiges of the encampments of the Romans may be distinctly traced at Bottlehill, at Waltonhill, and some other spots. Among the antiquities of later date, are the Palace of Lambeth, belonging to the see of Canterbury; that of Farnham, belonging to the see of Winchester; the remains of the Abbey at Croydon; the Castle of Guildford; Waverley Abbey, and some other Saxon edifices. The meadow of Runnymead, St Anne's Hill, the seat of the late Mr Fox, the park of Richmond, and the terrace there, with the palace and gardens of Kew, are all objects that excite a high degree of interest.

Titles and Representation.

The titles derived from this county are, Duke of Richmond, and Earls of Surry, Guildford, and Onslow: Two members are returned to the House of Commons from the county, and two each from the boroughs of Southwark, Guildford, Gatton, Ryegate, and Haselmere. It is difficult to say which is the county town. The elections are held at Guildford, and the assizes once in the year; the other assizes are held alternately at Kingston and at Croydon. The gaol is in the borough of Southwark, and county meetings are generally convened at Epsom.

Chief Seats.

The number of seats belonging to noblemen and gentlemen in this county is so great, as to forbid the noticing of even all those which in any other county would be deemed highly worthy of notice. The most remarkable are, his Majesty's palace of Kew; Claremont, Prince Leopold; Clandon Place, Earl of Onslow; Pepper Harrow, Lord Middleton; Oatlands, Duke of York; Painshill, Lord Carhampton; Ockham Park, Lord King; Busbridge, H. H. Townsend, Esq.; Addington Palace, Archbishop of Canterbury; Rooksnist, C. H. Turner, Esq.; Nonsuch Park, S. Farmer, Esq.; Gatton, Sir Mark Wood; Nork House, Lord Arden; Betchworth, Right Honourable H. Goulbourne; Norbury Park, Joseph Dennison, Esq.

Chief Towns.

The chief towns and their population are, Southwark, 85,905; Croydon, 9254; Richmond, 5994; Chertsey, 4279; Godalming, 4098; Kingston, 4908; Dorking, 3812; Farnham, 3132; Guildford, 3161; Ryegate, 2961.

See Manning and Bray's *History of Surry*; Salmon's *Antiquities of Surry*; Stevenson's *View of the Agriculture of Surry*; Lyson's *Environs of London*. (w. w.)

Surry ‖ Sussex.

Boundaries, Extent, Divisions.

SUSSEX, an English maritime county, bounded on the east by Kent, on the north by that county and Surry, on the west by Hampshire, and on the south by the British Channel. It is of an oblong shape, being about seventy miles in length from east to west, and no where more than twenty-six miles in breadth, from north to south. Its area is 1463 square miles, or 936,320 statute acres. It is divided into six portions, called provincially *Rapes*, which are again divided into sixty-five hundreds, and contain 313 parishes. The greater part of the county is within the diocese of Chichester; but the deanaries of Pagham and South Malling, and All Saints in Chichester, form a part of the peculiar of the Archbishop of Canterbury.

Population.

The number of houses in 1821 was 36,283, inhabited by 43,565 *families*; of whom 21,920 were chiefly employed in agriculture; 15,463 in trade, manufactures, or handicraft; and 6182 comprehended in neither of those classes. The number of inhabitants was 233,019, of whom 116,705 were males, and 116,314 females.

Face of the Country.

The northern part of the county was formerly wholly a forest, and still is very thickly covered with wood, and adorned with the finest oak trees in the kingdom. The soil is generally of so tenacious a clay, and so deep, that, until within a few years, in which roads have been made, and the navigation of the river Arun improved, the timber scarcely paid the expence of carriage to districts where it was needed. A range of chalk hills, known as the South Downs, runs through the county parallel to the coast, and in some points terminating in the sea. On these, vast flocks of sheep are fed; and in the small vallies intervening, the heaviest crops of wheat and other grain are raised. In the south-west part of the county, there is a track of arable land of most singular fecundity. On some parts of the coast, where the chalk hills recede from the shore, there are rich level plains, which feed some of the best oxen that supply the markets of the metropolis.

Landed Property.

The size of the estates vary much, but there are no very large proprietors. The farms in the weald or eastern vales are generally small, those on the South Downs as generally large. The average rent of the land, according to the returns under the late Property-tax, was 3s. 9d. *per* acre. More than 100,000 acres are not estimated at above 1s. 6d. *per* acre: 70,000 acres of down land are estimated at 6s. *per* acre, and 170,000 of woodland at 8s. *per* acre. The arable and woodland in the weald, amounting to about 420,000, are estimated at 12s. The marsh land and the arable land in the south-west have been let as high as 50s. *per* acre. In the weald about one-third is arable, one-third pasture, and one-third wood and waste land. On the south side of the Downs, the arable exceeds the pasture in the proportion of thirty acres to one.

Agriculture.

The agriculture of the county is as various as the differences of the soil. In the stiff lands of the weald,

the practice of fallowing is generally prevalent; but to the south of the downs it is rarely resorted to. The growing of turnips, potatoes, pease or beans, is commonly found sufficient to prepare the land for corn. Hops are very extensively cultivated in the eastern part of the county; and as nearly the whole manure of the farms is applied to that plant, the crops of wheat and other grain are usually scanty.

Cows. The cattle of Sussex are celebrated through the whole kingdom. The cows are of a deep red colour, with small heads, and horns, thin and transparent, which run out horizontally, and turn up towards the tips. The quality of their milk is not equal to that of some other breeds; hence, there are few dairies, and the cattle are chiefly reared for the sake of the meat, which is excellent. As much of the ploughing is performed by oxen, they usually labour in harness three or four years before they are fattened. They are but lightly worked, that their growth may not be impeded; and it is not unusual to see eight and sometimes even ten oxen to a plough.

Sheep. The sheep of Sussex have spread gradually over most parts of the island. The sheep, known by the name of South Downs, have no horns, and their faces and legs are black or dark coloured. The flesh is surpassed by none in England. Their wool is as fine as that of Herefordshire, and they require less food for their support than sheep of any other breed.

Employments. There are no manufactures in the county. The making of iron formerly gave employment to many persons in the weald; but the invention of making it with coke instead of charcoal has removed it to those districts where mines of iron and of coal are to be found. The only branch of industry that gives any employment to the population, besides that of agriculture, is the fishery, which, in the summer, especially when the mackerel appear, is extensive. The prosperity of many places on the coast has arisen from the crowds of visitors who frequent them, for the pleasures of sea air and bathing. Among those places Brighton, as the favourite residence of his present Majesty, is the most prominent; besides which, much company is annually collected at Hastings, East Bourne, Rottendean, Worthing, and Bognor.

Rivers. The rivers of Sussex are all streams of short course. The Lavant and Arun are navigable but a few miles from their mouths. The other rivers are the Adur, which, joining with the Ouse, runs by Lewes to Newhaven; and the Rother, which forms an estuary near Rye. The only canal is one that connects the towns of Petworth and Midhurst with the river Arun.

Antiquities. There are several remains of Roman camps in different parts of the county, and the Stane Street road may still be traced between Chichester and Dorking. The Saxon remains are very numerous, among which the most remarkable are Pevensey Castle, and Battle Abbey. Arundel Castle is a most splendid modernized edifice, upon the site of the ancient erection of that name. Besides these, Bayham Abbey, Eridge Castle, Bodiham Castle, and the buildings at Winchelsea, are worthy the attention of the antiquarian.

Titles and Representation. The titles derived from this county are—Duke of Sussex; Earls of Winchester, Ashburnham, and Chichester; Lords Arundel, Gage, Selsey, and Sheffield. The county returns two members to Parliament, and two for each of the following places, Chichester, Arundel, Bramber, Horsham, East Grinstead, Lewes, Midhurst, Shoreham, and Steyning.

Chief Seats. The most remarkable seats are, the Pavilion at Brighton; Goodwood, the Duke of Richmond; Petworth, Earl of Egremont; Arundel Castle, Duke of Norfolk; Sheffield Place, Earl Sheffield; Eridge Castle, Earl of Abergavenny; Ashburnham House, Earl of Ashburnham; Stanstead, Reverend Lewis Way; Parham, Sir Cecil Bishop; Kidbroke, Lord Colchester; Marisfield Park, Sir John Shelly; Firle, Lord Gage; Stanmer Park, Earl of Chichester; Ovingdean, Nathaniel Kemp, Esq.; Eartham, Right Honourable William Huskisson; Weshdean House, Lord Selsey.

Chief Towns. The most considerable towns and their population are, Chichester, 7362; Brighton, 24,429; Lewes, 7083; Hastings, 6085; Horsham, 4575; Battle, 2852; East Grinstead, 3153; Arundel, 2511; Rye, 3599.

See Young's *Agricultural Survey of Sussex*; Russel's *Description of Kent and Sussex*; Gilpin's *Observations*; Pennant's *Journey from London to the Isle of Wight*; *Beauties of England and Wales*. (W. W.)

Situation and Boundaries. SUTHERLAND, an extensive county in the north of Scotland, situated between 57° 53′, and 58° 36′ north latitude, and between 3° 39′, and 5° 15′ west longitude from Greenwich; having the sea on the south-east, west, and north, Caithness on the north-east, and Ross-shire on the south. From north to south it extends from 35 to 50 miles, and from west to east from 45 to 50, and contains, according to the latest authorities, which cannot, however, be depended on as accurate, about 1,800,000 English acres, divided into 13 parishes, which belong to the synod of Sutherland and Caithness. Of the other divisions, the principal are, Assynt and Edderachylis on the west, and Strathnaver on the east; names recognized by the inhabitants, and which still serve to designate the locality of the natural objects and other circumstances of the country.

Surface. The coast of Sutherland, like that of the other Highland counties of Scotland, presents a succession of inlets of the sea, and bold promontories, with a number of rocks and islets. The principal arms of the sea are Lochs Assynt, Laxford, and Inchard, on the west; Durness Bay, Loch Eriboll, the Kyle of Tongue, and the bays of Torrisdale and Strathy on the north; and Loch Fleet in the Frith of Dornoch, on the south-east: and the more remarkable promontories are, Ru Stoir, on the south side of Loch Assynt; Cape Wrath on the north-west extremity of the county; Far-out Head, and Whitten Head, on the north; and Strathy Head on the north-east. The interior consists of mountains, mosses, lakes, and streams, presenting great variety in form, but almost all having the same general character of being barren, rugged, and dismal, more especially on the western side; and so closely thrown together, that there is no valley of any extent, and seldom a tree or a shrub to relieve the eye. The Assynt mountains have not even heath to cover their naked-

Sutherland-shire.

ness, except in patches among the rocks near their base. Some exceptions to this general character occur on the eastern coast, along the Dornoch Frith, and on the banks of a few of the lakes and rivulets; but in a general view, these are so inconsiderable, that, according to the writer of the *Agricultural Report*, the cultivated land, green pastures, and woods, do not much exceed 60,000 acres, or about one-thirtieth part of its area; and the cultivated land alone is little more than one acre in a hundred. The climate of the east coast, however, is not so severe as to prevent the growth of wheat, which sometimes ripens as early here as in many parts of England.

Rivers.

The principal streams are, Oickel, Fleet, Brora, and Helmsdale, which fall into the Dornoch Frith on the south-east. The tide renders the Oickel navigable by vessels of 50 tons, for about 12 miles, and for boats for about eight miles farther; and they have all good salmon fisheries. These rivulets have their source among the mountains, in the centre of the district, and flow south-east. In the same quarter a number of streams take their rise, and flow north; such as Strathy, the Naver, which gives its name to the tract called Strathnaver, the Dinart, &c., most of them containing salmon. The most considerable lake is Loch Shin, about 20 miles long, and one broad, situated on the southern side of the county, through which flows a stream of the same name, which falls into the Oickel. There are several others of considerable extent in different parts, the whole occupying about 47 square miles, or upwards of 30,000 acres.

Caves.

On the north coast the sea has formed some remarkable caves in the limestone rock, particularly one at Smow, to the east of Balnakeel of Durness, 32 yards wide, and 20 yards high; and another at Fraisgill, 50 feet high, and 20 feet wide at its entrance, but contracting by degrees till its termination, more than half a mile under ground.

Minerals.

Coal, limestone, marble, and sandstone, are found in Sutherland; and it is supposed to contain other minerals, which either have not been explored, or turned to any account. On the rivulet Brora coal is now worked to some extent; and connected with these works, a railway has been recently formed from them to the harbour at its mouth, with saltworks, at which the small coal is consumed. Limestone of a good quality abounds on the coast, and is also found in some parts of the interior. At Leadmore and Lead-beg, in Assynt, excellent marble, some of it white and pure as alabaster, has been wrought by Mr Jopling from Newcastle; and a black kind, streaked with yellow veins, occurs in Edderachylis. Clay fit for bricks, tiles, and the coarser kinds of pottery, is also found on the east coast upon the Sutherland estate.

Valuation and Rental.

This county, which is valued in the cess-books at L. 26,193, 9s. 7d. Scots, is divided among 13 proprietors. Of this valuation the Sutherland estate, belonging to the Marchioness of Stafford, Countess of Sutherland in her own right, is almost two-thirds, and that of Lord Reay nearly a seventh part. The former contains about 890,000 English acres. Skibo, Bighouse, and Strathy, are each above L.500 Scots, the others under that valuation. In 1812 the gross rental of the lands and houses, as returned under the Property-tax Act, was L.28,458, 8s. 4d. including about L.1700 as the rent of the salmon and other fisheries. More than half the valuation is held under entail.

Seats.

The principal seats are Dunrobin Castle, the Marchioness of Stafford, on the coast of the Dornoch Frith, in the parish of Golspie; Skibo, Dempster, on an inlet of the same frith, near the south-eastern corner of the county; and Tongue Castle, Lord Reay, on the Kyle of Tongue, on the north coast. Most of the other proprietors have good modern houses, all of which are situated near the coast. In no part of Britain has a greater change been effected in so short a period as in Sutherland, and this chiefly by the spirit and liberality of its greatest proprietor, the Marquis of Stafford. Within these twelve or fourteen years, roads, bridges, harbours, and villages, have been constructed wherever they seemed to be required; and both the natural and moral obstructions to the improvement of this extensive territory have, as far as it appears practicable, been in a great measure overcome.

In this, and in some other parts of the Highlands, there is still a class of landholders called *wadsetters*, once numerous in the other counties of Scotland. These men, having advanced money to the owner of an estate, obtained from him a temporary right to a certain portion of it as a pledge for their security, corresponding in yearly value to the interest of the money lent, and subject to redemption upon its repayment. The practice of granting securities of this kind has long since fallen into disuse; but several of them still subsist, or subsisted very lately, upon the Sutherland estate, especially upon the south-east coast. Lands of L. 200 Scots valuation, instead of L. 400 Scots, as in other counties, afford a vote in the election of a member for Sutherland, whether held of the Crown, or of the Earls of Sutherland.

Tenantry.

The tenantry include nearly all the other inhabitants; and small as is the population of this county, the number of these tenants is out of all proportion to the extent of the productive land. Excepting along the south-east coast, where there is a stripe of arable land, seldom so much as a mile in breadth, there is nothing that deserves the name of an arable farm; and scarcely any where as much and lying contiguous as would form one; the valleys in which the waters flow being very narrow, and the soil often of an inferior description, besides being exposed to inundations from the swelling of the mountain torrents. Yet these valleys or straths, in many instances, are tenanted at the rate of one family for every acre of arable land; the people living in miserable huts, without chimneys or windows, under the same roof with their live stock, which pasture on the higher grounds; and cultivating the ground for oats, bear, and potatoes, with a crooked spade, or *cascrom*, instead of the plough; their cattle perishing for want in hard winters, and themselves sometimes reduced to the necessity of living upon their blood. Such is the system that prevailed till lately over all the Highlands of Scot-

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land, and which, though giving way, still prevails over a great part of Sutherland. The change, where it has occurred, has been owing to the introduction of sheep; of which there are now several considerable flocks, chiefly of the Cheviot breed, which, under proper management, are found to answer, notwithstanding the severity of the climate. Much loss, however, was sustained by the earliest adventurers in this line, chiefly, it is alleged, from the hostility of the natives; and eagles and other birds of prey, and foxes, still commit great ravages among the flocks. The number of sheep has been computed to be about 140,000, producing about 18,000 stone of wool, of 24 lbs. *per* stone. Of the rent paid by the small tenants on the south-east coast the exact amount cannot be ascertained; the arable land not being let by the acre, but by the quantity of grain that may be sown; which is at the rate of from 15s. to L. 1, 1s. *per* boll, paid partly in money, and partly in oatmeal and bear; but to this we must add personal services, customs and casualties, exacted by the tacksman or the landlord. In other parts of the county, where the proportion of arable land is still much smaller than on the south-east, the tenants pay in proportion to the number of black cattle they can rear and maintain; these affording the only surplus for the landowners. It is the general practice to make butter and cheese, and to rear a calf for every two cows. The quantity of butter is from 24 to 48 lbs. avoirdupois, and of cheese, about twice as much *per* cow. "The leases between the proprietor and principal tacksman," says Captain Henderson, "are generally 19 or 21 years, but the tacksman seldom gives a lease to his subtenants or cottars, and when he does, it is generally for three, five, or seven years. This is done with a view of making them submissive in performing personal services, &c."

Sheep Farming.

Manufactures.

Until the recent establishments of the Marquis of Stafford, which are still in their infancy, there was no manufacture in this county, if we except that of kelp, of which the quantity used to be 250 tons. A cotton mill had been erected at Spinningdale, on a branch of the Dornoch Frith, by a Glasgow company, but the building having been burnt down in 1806, the undertaking was abandoned. A good many boats are employed in the fisheries on the west and north coast for cod, ling, haddock, and herring; and lobsters and muscles are got in considerable quantities. At Helmsdale, on the east coast, many of those small tenants who were removed by the introduction of sheep farming have also embarked in the fisheries with considerable success; and large sums have been expended within these few years by the noble proprietor of the Sutherland estate in erecting the necessary buildings. The principal exports are cattle, horses, sheep, wool, salmon, and cod; their butter and cheese are nearly all consumed at home; and besides the usual imports of cloths, groceries, &c., they require some corn, chiefly oatmeal, especially on the west and north sides of the county, where they have very little corn land. Dornoch, a royal burgh, situated on the south-eastern extremity, on the Frith of that name, is the only town, and contains little more than 500 inhabitants. Golspie, Helmsdale, and Brora, are the principal villages. With these exceptions, the inhabitants are scattered along the coast, and, in some of the principal straths, passing much of their time in idleness; a healthy, robust, and simple, though not ill informed race, who have contributed largely to the public service. For the last half century, the Earls of Sutherland have raised among them, at the commencement of every war, a corps of 1000 men, well known by the name of the Sutherland Fencibles; but this spirit, founded in attachment to their chiefs, has now become much weaker than formerly.

Fisheries.

Commerce.

Sutherland-shire || Sweden and Norway.

Representation.

The county, in which the number of voters may vary from 20 to 25, sends one member to Parliament; and the town of Dornoch joins with Dingwall, Tain, Wick, and Kirkwall, in electing one for the Scottish burghs.

Population.

The population, according to the census of 1801, was 23,117; in 1811 it amounted to 23,629; and in 1821 to 23,840, of which 11,088 were males, and 12,752 were females. The *families* employed in agriculture were 3362; in trade and manufactures 642; in all other occupations 818. The increase of population from 1811 to 1821 was only 211.

Antiquities.

There are some remains of antiquity in various parts along the coast. The most interesting are two circular buildings, called Dun Dornadil, or Dornadilla's Tower, and Castle Coll, both reared of large stones, nicely fitted, but without cement, and of which considerable portions are still entire, after the lapse of probably 1000 years. Castle Coll, which is situated on the east side of the county, on a stream that falls into the Brora, has an exterior circumference of 54 yards, with walls four and one-half yards thick at the base, inclining inwards nine inches in every three feet in height; and two small apartments on each side of the door-way, as if intended for guard-rooms. The highest part of the wall is now only eleven feet high, but old people remember it twice that height. Dun Dornadil is in the parish of Durness, on the northern side of the county. It is a building of the same character with the former, but still more dilapidated, and is celebrated in the ancient Gaelic ballads as a place of renown at a very early period. The ruins of Dornoch Cathedral still display the original grandeur of that edifice, which is said to have been built in the eleventh century, and repaired and enlarged in the thirteenth. Circular cairns with subterraneous passages, tumuli, and some small forts, may yet be traced in various situations along the coast.

See the general works quoted under the former Scottish counties; Henderson's *General View of the County of Sutherland;* and Loch's *Account of the Improvements of the Marquis of Stafford in Sutherland.* (A.)

Recent Changes.

SWEDEN. The recent changes that have been produced in this monarchy consist of the loss of Finland, conveyed by cession to Russia, as a condition of peace, with that of Pomerania, now subject to Prussia; and the acquisition of Norway, as the price of the services of Sweden in the struggle which terminated with the downfall of Buonaparte.

Sweden and Nowray.

As the inhabitants of Norway discovered an aversion to becoming subject to the kingdom of Sweden, assurances were given that their ancient usages and privileges should be preserved to them; and that, though united with Sweden under the same monarch, the legislative power, the finances, the national debts, the laws, the army, and other establishments, should be maintained distinct, and almost every purpose of an independent nation be preserved.

Bernadotte, one of the Generals of the French army, had been chosen, by the senate and the king, Charles XIV., as Crown Prince,] or successor to the throne; perhaps without any intrigues on his own part, but certainly without any on the part of the French Emperor, chiefly on account of the reputation he had acquired through the north of Europe, by his wise and humane conduct whilst exercising the military power in Hanover. On the demise of Charles, after his co-operation with the allies in the deliverance of Europe, Bernadotte mounted the throne, and seems to have succeeded in uniting Sweden and Norway under his government, and in establishing in his family the succession to the crown.

Divisions.

The Swedish geographers divide the kingdom into three portions, called by them the North, the Middle, and the South Provinces. These are again divided into districts, according to their political and fiscal relations, denominated *Laens* or Stadtholderships; but the ancient distinction of provinces is still kept up among the greater part of the inhabitants.

	Laens.	Extent in Square Miles.	Population.	Capitals.
Middle Sweden.	Stockholm city, Drottingsholm, Stockholm district -	2,624	172,029	Stockholm
	Upsal -	2,261	84,128	Upsal
	Westeras	2,793	84,808	Westeras
	Nykoping	2,880	98,761	Nykoping
	Orebro -	3,670	100,428	Orebro
	Carlstad -	6,550	140,100	Carlstad
South Sweden.	Gottenburg	1,835	119,514	Gottenburg
	Elfsborg -	3,008	156,271	Menersborg
	Staraborg -	3,207	138,410	Mariestad
	Linkoping	4,305	162,859	Linkoping
	Calmar -	4,181	136,296	Calmar
	Joenkoping	4,267	117,381	Joenkoping
	Cronoberg -	3,495	89,631	Merioe
	Carlskrona -	1,088	63,824	Carlskron
	Gothland -	1,045	32,988	Wisby
	Halmstad -	1,963	73,594	Halmstad
	Christianstad	2,174	120,547	Christianstad
	Malmoe -	1,750	149,892	Malmoe
North Sweden.	Falun or Storakopparberg	12,587	124,816	Falun
	Gefleborg -	7,765	79,000	Gefleborg
	Jaemtland -	18,261	32,000	Oestersund
	Norrland -	10,496	62,000	Hernoesand
	Maester, and Nordbottens	64,597	76,000	Umeae

Sweden and Norway.

The places containing more than 3000 inhabitants, and their population, are as follows:

Stockholm, 65,474; Gottenburg, 17,760; Carlscrona, 10,553; Norrkopping, 9428; Gefleborg, 5930; Malmoe, 4932; Upsal, 4897; Falun, 4709; Uddewalla, 3971; Wisby, 3819; Landskrona, 3776; Carlsham, 3387; Orebro, 3242; Lund, 3224; Christianstad, 3106; Calmar, 3058.

Population

There are 88 places denominated cities, and four called market towns. They are mostly small, except the few above enumerated. The inhabitants of these cities and towns, according to the tables of 1815, were 248,029, making about one-tenth of the whole population; and the other nine-tenths were living in 2214 parishes, containing 65,284 farms. At the same period the classes of the people are thus indicated. Learned, including clergy, professors, students, and servants, employed in the churches, with their wives and children, 25,986; civil officers, 24,652; military of all ranks, 113,465; sailors, 22,178; burgesses, including manufacturers, merchants, tradesmen, handicraftmen, and their several apprentices, 160,922; private persons, including retired officers and tradesmen, owners of estates, funded property, or mortgages, 79,814; peasants, 1,391,606; domestic servants to the nobility and gentry, 43,659; poor, and prisoners, 24,131; orphan, and foundling children, 13,757; and females who are either single or widows, with their children, 555.496. By a table, the data for which were collected in 1810, it appeared that the families were 451,116; that the learned classes formed 1 in 110 of the males; the civil officers, 1 in 140; the military, including the militia, 1 in 27; the tradesmen, 1 in 260; the farmers, 7 in 10; the domestic servants, 1 in 44; the workmen in factories, 1 in 52; the sailors, 1 in 146; the poor, 1 in 60; and the children one-eighth of the whole male population.

Production

Not more than one-twentieth part of the surface of Sweden is capable of cultivation, and of that only one-half is actually cultivated. The harvests are by no means productive, and estimated by Akrel to yield not more than five times the seed that is sown in good years. In a cycle of ten years, the same writer states, that one of them fails, two are scanty, five are moderate, and two are abundant. The deficiency of corn for the support of the inhabitants compels them to mix the rind of the *Pinus silvestris*, and the roots of some bog-plants, with their flour, to eke out their scanty stock of food. The extensive cultivation of potatoes, which has taken place of late years, has been found to afford most valuable aid to the general subsistence. Hemp, flax, and tobacco, are grown for domestic use. Hops are cultivated and exported to Denmark and Germany. The breeding of cattle is a productive branch of industry, though the races of horses, cows, and sheep, are generally small in size. The stock of cattle was as follows, soon after the loss of Finland: horses, 405,030; oxen, cows, and calves, 1,312,594; and sheep and lambs, 1,243,315: goats and pigs are thinly scattered. In the north, the reindeer is a valuable domestic animal: some proprietors have herds of more than 1000, which are fed through the winter on the moss, which instinct teaches them to find under the deep snow. The fisheries yield employment, subsistence, and articles for export; but,

Sweden and Norway.

of late years, the shoals of herrings have greatly diminished. The chief production of the soil is timber, as two-thirds of the surface is covered with woods. The far greater part of the dwellings are composed wholly of wood; the demand for fuel is very great; and yet the export of planks, masts, pitch, tar, potashes, and charcoal, forms the chief part of the foreign trade. The mines of Sweden have long been worked, and have suffered little increase or diminution of late years. Their average products have been 64 ounces of gold; 12,900 ounces of silver; 24,800 quintals of copper; 431 quintals of lead; 100,000 tons of iron; 22,000 quintals of alum; 35,000 tons of coal; and 65,000 quintals of saltpetre. The manufactures of Sweden are confined to the few articles required for the scanty supply of its needy population. Cloths, cottons, silks, and linens, and many smaller articles, are furnished from the different fabrics within the kingdom, whose annual amount is calculated to be about L. 280,000 Sterling. The merchant ships, in 1816, were 1107; their burden 64,290 lasts, and their crews 9014 men and boys.

Productions.

Government.

The government is a limited monarchy, hereditary in the male line of Bernadotte; but in case of the failure of males in that family, a successor is to be nominated by the King, and approved by the Legislature. The appointed civil list for the King is 320,000 rix dollars banco, or about L. 50,000 Sterling; that of the Crown Prince one-third of that sum. The States are composed of 1100 Nobles, 50 to 80 Clergy, from 100 to 200 Burgesses, and 100 Peasants, who vote by classes, not by the head. They necessarily assemble every fifth year, and more frequently if convened by the King. They make laws, grant taxes, regulate the coinage and the press, and superintend the administration of justice. The laws are contained in a volume of 480 pages, which is looked up to with much veneration from its antiquity, having been adopted as early as the year 1442. All new cases of differences that occur are referred to the principles contained in this fundamental code. There are courts of revision and courts of appeal, whose judgment is final.

Religion and Education.

The established religion is the Lutheran, but since the year 1799 all other sects have been tolerated. It is modified somewhat in a manner different from what exists in Germany, and approaching in its government more nearly to the English Church. There are twelve Bishops and one Archbishop, that of Upsal. The benefices are endowed with the tithes, and the condition of the clergy is respectable. The University of Upsal is the highest seminary, containing twenty-four professors. The University of Lund has twenty-two professors. In these establishments, the system pursued differs from that of the German universities, both in the length of time required for a degree, and the restrictions upon the conduct and attention of the students. In most of the Episcopal cities there are endowed classical schools. In all the towns there are burgher schools, and in the parish churches in the villages; in which the Lancasterian method of teaching reading and writing has been successfully introduced.

Army.

The army, at present, is reduced, and consists of 3505 cavalry, 24,144 infantry and artillery, and an extraordinary division of 3387 men of all arms. The army may be made up in war by the reserve and recruiting to 100,000 men. The navy, which, in 1806, had sunk from 20 sail of the line to 13, since 1799, is now so much further reduced, that there are scarcely six sail fit to be sent to sea, and eight or nine frigates. There are a considerable number of gun-boats and other flotilla, calculated to convey land forces.

Finances.

The expences of the government are very rigidly watched, and have recently been considerably reduced; at present they stand on the following scale:

Establishment of the Royal Households,	L. 210,000
For the Senators and the Government,	180,000
For the Judicial and Police Branches,	50,000
For the Military Branch,	370,000
For the Marine Branch,	180,000
For Extraordinary Expences, including Interest on the Public Debt,	150,000
	L. 1,140,000

The public income is nearly commensurate with the expenditure on an average of years. It is derived in a small degree from national domains, from a land and capitation tax, from duties on imports which are let to farm, from stamps, from taxes on liquors, from the monopoly of saltpetre, from the mines, and some smaller sources. The public debt, on 16th April 1819, amounted to 6,371,862 Reichsthalern Banco, or about L.1,387,500 Sterling; having been reduced L. 250,000 since the year 1813. It is wholly owing to residents in Sweden; and, on the plan of a sinking fund now in progress, will be extinguished in fourteen years. The chief financial evil under which the kingdom suffers, is from the vast quantity of paper money which circulates, and which has driven out the metallic money. Measures are adopted by which this paper is gradually withdrawn by the bank, for accomplishing which, certain extraordinary taxes are appropriated.

See *Erdebeschreibung*, von Gasparai, &c., Weimar, 1822; Swerige's *Civil och Krigskalender for Arct*, Stockholm, 1819; *Utkast til en Svensk statistik, Första Afdelingen*, Stockholm, 1818; Thomson's *Travels in Sweden*, London, 1814.

Norway.

Norway.

When the power over Norway was assumed by the Swedish monarch, its independence of Sweden was secured by resolutions of the States, or the Storthing, guaranteed by the King on the 4th November 1814. These fundamental rules decree, 1st, That only citizens of Norway, of the Lutheran religion, shall be nominated to fill any office. 2d, That Norway shall be answerable for its own national debt alone. 3d, That none shall be judged but by the law, and that torture shall not be practised. 4th, That no retrospective law shall be enacted. 5th, That no one shall be arrested, or confined, but in cases specified by the law. 6th, The liberty of the press shall not be infringed. 7th, Landed property shall not become forfeited. 8th, No nobles shall be created. 9th, Each Norwegian, without regard to

Sweden and Norway.

rank or wealth, is bound to serve a certain time to be fixed. 10th, Norway shall retain its own bank and coins. 11th, Norwegian merchant ships may carry their own national flag.

Under these stipulations, Norway is a limited hereditary monarchy, in which the executive power is vested in the King, and the Legislature in the States, or Storthing. The King exercises his power through a Viceroy, who resides in the royal palace at Christiana. The members of the Legislature are chosen by electors, who are nominated for that purpose by those who have a right to vote. In the cities, the number of electors to be chosen is one to every fifty voters; in the country, one to every hundred votes. These electors choose the deputies for the respective districts; from five to fourteen electors choose one deputy; from fifteen to twenty-four, two deputies; from twenty-five to thirty-four, three deputies; and from thirty-five upwards, four deputies, which is the greatest number that any electoral assembly can nominate. The deputies must be thirty years of age, and have resided the last ten years within the kingdom. Whoever is chosen is bound to serve. They are free from arrest, and are paid for their time and travelling expences. The number of the representatives of the country are as two to one of those from the cities. The whole number is from 75 to 100. The servants of the Crown, the Members of the Council, and Pensioners, are ineligible. The assembly meets every third year on the first working day in February. There are two chambers, or bodies, one called the Lagthing, consisting of one-fourth the members, the other called the Odelsthing, comprehending the other three-fourths. All laws must originate in the Odelsthing, from its own members, or from the suggestion of the King; but the assent of the other body is required for their enactment. The forms of passing laws are complicated, but they insure great deliberation. The assembly continues its session three months, but the King may prolong it beyond that period, or call it together in the intervals of the regular assemblings. The Senate, appointed by the King, is rather an executive than a legislative body, but must consist of Norwegians.

The expences of the government are nearly equal to the income, both being about L. 300,000 Sterling *per annum*. The revenue arises principally from a territorial impost, and from duties on importation and consumption, which amount to three-fourths of the whole. The national debt is in annuities, amounting to nearly L. 10,000 *per annum*. It would be speedily redeemed but for the great mass of paper money in circulation, which had depreciated it to such an extent, that, in 1817, one silver dollar was worth ten paper dollars. Attempts have been made by the establishment of a national bank to remedy this evil, but its success has been hitherto very slight.

The army consists of 12,000 men, of whom 2000 form the garrisons of the several fortified places. The militia amount to 7000. The navy of Norway consists of six brigs, eight schooners, and about forty gun-boats, with some smaller flotilla.

Sweden and Norway ‖ Swisserland.

The religion is Lutheran, and the ecclesiastical affairs are under the superintendence of five bishops. The provision for the clergy is scanty, and many of the parochial churches are consequently destitute of pastors. The University of Christiana has sixteen professors, and somewhat more than 100 students; and the seminaries of Tönsberg and of Töten assist in providing education for the gentry and clergy. In each of the episcopal cities there are endowed schools.

Norway is divided into four provinces, called Stifts, viz.

Stifts.	Extent in Square Miles.	Population.	Capitals.
Aggerhaus......	32,789	378,646	Christiana
Christiansand...	10,304	117,852	Christiansand
Bergen	13,397	130,959	Bergen
Drontheim......	21,163	161,287	Drontheim
Nordland	42,667	78,425	Alstahoug

The account published by the Storthing, in 1819, makes the inhabitants 910,000, but in that number is included the army and navy. The towns, proportionally to the whole population, are well filled with inhabitants; especially those where the iron-works or the trade of sawing and shipping timber, which is the chief commerce, is carried on. The names and population of the places containing more than 4000 inhabitants are, Bergen, 18,080; Christiana, 10,638; Drontheim, 9000; Töten, 7832; Kongsberg, 6810; Ourdal, 6169; Benger, 6149; Hoff, 6009; Drammen, 5412; Näss, 5409; Oudalen, 5164; Land, 5119; Alstahoug, 4993; Christiansand, 4844; Borgen, 4864; Grue, 4706; Homnay, 4561; Brönoe, 4386; and Oal, 4086.

See *Thaarups danske Monarkies Statistik, etc.* Kiobenhaven, Vol. VIII. 1815; *Reise durch Norwegen und Lappland*, von Leopold von Buch, Berlin, 1810; *Gemahlde von Norwegen von einem geborenen Normann*, Hamburg, 1815; Gaspari's *Erdebishreibung*, 10 vol. 1822, Weimar. (w. w.)

Swisserland.

SWISSERLAND, or SWITZERLAND. This league of independent states, whose constitutions, both local and general, had been overturned in the course of the French Revolution, and a part of whose territory had been added to France, has been reinstated by the Congress of Vienna in its former independence, and has received additions of territory. This settlement has led to new divisions, and the Swiss Confederacy at present consists of twenty-two cantons, whose names, extent, population, and capitals, are as follow:

Swisserland.

Cantons.	Extent in Square Miles.	Population.	Capitals, and their Population.	
Zurick	960	182,080	Zurick	10,470
Berne	3,690	291,600	Berne	13,000
Lucerne	768	99,970	Lucerne	5,000
Uri	512	14,600	Altorf	3,000
Schwitz	470	28,900	Schwitz	4,640
Unterwalden	260	21,200	Sarnen	3,000
Glarus	453	24,000	Glarus	3,000
Zug	125	14,750	Zug	2,500
Fryburg	490	89,600	Fryburg	6,460
Solothurn	277	48,600	Solothurn	4,100
Basle	266	49,200	Basle	16,200
Schaffhausen	170	30,000	Schaffhausen	5.500
Appenzell	223	55,000	Herisau	7,000
			Appenzell	3,000
St Gall	853	130,800	St Gall	9,000
Grey League	2,986	73,200	Chur	3,350
Aargau	768	143,960	Aarau	3,000
Thurgau	357	77,090	Frauenfeld	1,800
Tessino	1,183	88,790	Lugano	3,400
Vaud, or Waadt	1,493	141,670	Lausanne	9,960
Vallois, or Wallis	1,962	62,800	Sitten, or Sion	2,500
Neufchatel	320	50,000	Neufchatel	5,150
Geneva	95	40,000	Geneva	22,000
	18,681, or 11,955,840 acres.	1,757,810		

The only other towns whose population exceeds 3000 inhabitants are in the canton of Zurick; Horgen, with 3700; Wädenschwyl, 3460; Stäfa, 3360; and Wald, 3200; in the canton of Vaud, Vevay, with 3780; and in the canton of Geneva, Carouge, with 3200 souls.

Government. Each of the cantons has its own system of government and laws; but they all form a general community, by means of representatives chosen from each of them, who meet to regulate the external relations of the union, and to provide the means, both in troops and money, for the general defence.

The delegates from the different cantons assemble yearly in July, or more frequently, on the requisition of any five of them. Treaties of peace, or declarations of war, require the assent of three-fourths of the votes. All other matters are determined by majority. The place of meeting is in rotation, Zurick, Berne, and Lucerne, each for two years, where the supreme court is held, and the Chancellor and State-Secretary hold their offices.

Forces. Although every man capable of bearing arms is a soldier, and occasionally trained and exercised, yet a more disposable force is arranged, to which each of the cantons must furnish their proportion, at the rate of two men out of every hundred of the appropriate age. These form an army, when required, as follows:

Artillery	32 companies	2,272 men.
Sappers	2 do.	142
Pontoniers	1 do.	71
Carry forward		2,485
Brought forward		2,485
Train		1,400
Light Cavalry	17 troops	1,088
Sharpshooters	10 companies	1,000
Infantry	204 do.	25,199
Yagars	20 do.	2,000
Staff Corps		586
		33,758

The militia, mustered under the direction of each individual canton, amount together to 67,516 men, besides which is the landwehr, or *levy en masse*, which comprehends the whole of the male population. In order that the military spirit of the Swiss may not become dormant, the cantons have permitted great numbers of their young men to enter into the service of foreign states. In the year 1816 the numbers so engaged were estimated to be about 30,000; of whom 12,370 were in France; 10,000 in the Netherlands; 430 in Prussia; and the others in Spain and Sardinia. The expences of the general government are defrayed by contributions from each canton, according to their estimated wealth, which, as well as the military contingent, is adjusted to existing circumstances at the termination of every period of twenty years. The revenues, expences, and debts of the several cantons, are generally kept with much privacy, and the taxes are various, but in general very light.

Religion. The cantons of Lucerne, Uri, Schwitz, Unterwalden, Zug, Fryburg, Solothurn, Tessino, and a part of Appenzell, adhere to the Roman Catholic church. The reformed Protestant church is established in

Zurick, Berne, Basle, Schaffhausen, Vaud, Neufchatel, Geneva, and a part of Appenzell. Both religions are established in Glarus, Thurgaw, Aargau, St Gall, and the Grey League, but in them the majority of the people are Protestants. The number of the Reformed or Calvinists are estimated to be 1,046,000; of the Catholics 682,000; and in the remainder are comprised a few Lutherans, Anabaptists, and Jews.

Productions and Trade.

As Switzerland does not grow sufficient corn for its own subsistence, though its harvests are eked out by the recent extension of the culture of potatoes, that necessary article is supplied to it from the neighbouring states; to which it makes returns in the products of its soil, wine, live cattle, butter, and cheese. Besides these it sells some manufactures, the principal of which are various cotton goods. These are chiefly produced in Zurick, St Gall, Berne, and Appenzell, where extensive machinery is constructed both for spinning and weaving. Some of the goods produced in Switzerland are the most successful in rivalling the fabrics of Lancashire and Glasgow at the great fairs of Frankfort and Leipsic. In the cantons of Thurgaw and St Gall there are many manufactories both of fine and coarse linen. Silk goods of various descriptions are made in Basle, in Schaffhausen, and Lucerne, but especially in Tessino, where the raw material is produced; but this description of productions has of late suffered a great declension. Watchmaking gives employment to more than 4000 workmen in Geneva, and to as many in Neufchatel and other places. The number of watches annually sent from Switzerland is estimated to be about 250,000. These means of subsistence and employment are found insufficient to check the progress of poverty, which is making rapid strides, and which has produced extensive emigrations to the United States of America, to Canada, and to Brazil.

See Simond's *Switzerland*; Körner *kürze Erdbeschreibung der Schweiz*; Ehrmann *neuste Kunde der Schweiz und Italien*; Uteri *handbuch des Schweiz Staatsrects.*

(W. W.)

TAXATION.

Definition.

A TAX is a portion of the produce of the capital and labour of individuals, taken from them by authority of Government, and placed at its disposal.

A tax may be either *direct* or *indirect*. It is said to be *direct* when it is immediately taken from income or capital; and *indirect* when it is taken from them by making their owners pay for liberty to use certain articles, or to exercise certain privileges.

A tax may be either *general* or *particular*—that is, it may be made either to affect all classes indiscriminately, or to affect only one or more classes.

TAXATION is the general term used to express the aggregate of particular taxes. It is also the name given to that branch of the science of Political Economy which explains the mode in which the revenue required for the public service may be most advantageously raised.

PART I.—GENERAL OBSERVATIONS ON TAXATION.

Necessity of Taxation—Present System of Taxation originated in the decline of the Feudal System—Taxes estimated by Values, and not by Quantities—Every Improvement in the Arts, a Means of enabling a Country to bear Additional Taxes—Opposite Effects of Moderate and Heavy Taxes—Fallacy of the Doctrine of those who contend that Taxes are not really lost to the Contributors, but that they are again restored to them by the Expenditure of Government or its Agents—Erroneous Opinion of Locke and Quesnay with respect to the ultimate Incidence of all Taxes on the Land—Maxims to be observed in the Imposition of Taxes—Agreement or Disagreement of certain Taxes with these Maxims—Excise Scheme of Sir Robert Walpole—Expence and Mode of collecting Taxes—Corvées.

Necessity of Taxation.

We conceive it would be quite superfluous to enter into any lengthened argument to show the utility, or rather necessity, of raising a revenue for the use of the public. It is sufficient to observe, that security from foreign invasion, the speedy and impartial administration of justice, and the maintenance of good order and tranquillity, are absolutely indispensable to the successful exertion of industry, and to the advancement of society in the career of civilization and refinement. And when such is the case—when it is admitted on all hands, that security and good order are productive of *universal* advantage—and that, without them, there could be no considerable accumulation of national wealth—it is plain no individual can justly complain that he is made to contribute, in the same proportion to his means as others, for their attainment; or, which is the same thing, that he is made to pay his fair share of the sum required to procure the services of the soldiers and sailors necessary to repel hostile aggression; and to support the various institutions and public functionaries necessary to maintain the internal peace of the country, to promote its prosperity, and to protect every citizen in the undisturbed enjoyment of his property and rights. It is certainly true, that the public are frequently made to contribute larger sums than are necessary for the ends of good government. But, as this abuse must obviously originate either in the misconduct of administration, or in the defective political organization of the State, it does not properly come within the scope of our inquiries. In treating of taxation, the object of the Political Economist is not to inquire whether the revenue raised by the State exceeds its necessary wants, or whether it has been judiciously ex-

General Observations on Taxation.

pended; but to point out the general effect of taxation on individual and public wealth; and, by analyzing the various methods in which a revenue may be raised, and comparing them together, to show which is most advantageous, or rather which is *least injurious*, to the State.

Present System of Taxation rose out of the Decline of the Feudal System.

The scheme of taxation now in force in modern Europe had its origin in the decline of the feudal system. According to the principles of that system, all the lands of a country were held by their actual possessors as fiefs of the Crown, on condition of their performing certain stipulated services; of which the obligation to support the sovereign when he took the field, with a body of retainers, armed and maintained at their own expence, was by far the most important. The tenants in chief of the great fiefs, or those who held directly under the sovereign, were either originally invested with, or subsequently usurped, the prerogative of distributing justice in their respective lordships; and, in those days, the administration of justice, instead of being a source of expence, became, in consequence of the corruption and abuses with which it was infected, a considerable source not of influence only, but also of emolument. The expence of the clergy was either defrayed from the produce of their own estates, or by a tithe levied from the estates of others. And the labour of the peasantry, during a few days before and after harvest, sufficed to put the roads and bridges into that state of repair, which the depressed situation of commerce, and the little intercourse between the different parts of the country, seemed to require. Nor was it even necessary to levy a tax for the support of the monarch and his court. The produce of the Crown estates, or of the royal demesnes which had not been feued to others, but which remained in the immediate possession of the sovereign, were generally sufficient to defray this part of the public expenditure. When the feudal system was in its vigour, the demesnes of the Crown were, in most countries, very extensive; and the alienations occasioned by the profusion of some princes, and the thoughtlessness of others, were compensated by the forfeitures and escheats that were always taking place.

The vicious and defective nature of this system of policy is too obvious to require to be pointed out; and it had for a long series of years the most destructive influence on the peace and prosperity of Europe. But the progressive, though slow, advance of civilization, ultimately led to its overthrow. Money payments were gradually substituted for personal services; and the institution of standing armies, in France,* by Charles VII., an institution which was soon after introduced into other countries, entirely broke the power and spirit of the feudal aristocracy; and enabled the different governments to introduce a regular plan of government, and to impose that system of pecuniary contribution now universally established.

General Observations on Taxation.

Taxes estimated by Values, and not by Quantities.

The amount of a tax is not to be estimated by the *bulk* or *species* of the produce transferred from individuals to government, but exclusively by its *value*. A heavy taxation consists in the abstraction of a large value, and a light taxation in the abstraction of a small value. When a fall takes place in the cost of producing any particular commodity, its price necessarily declines in an equal degree; and, supposing the value of money, the medium in which taxes are most commonly estimated, to continue invariable, the producers will be obliged to dispose of a proportionally larger quantity of that commodity whose price has fallen, to obtain the means of paying the same amount of taxes. It is plainly, however, an error to suppose, as is very commonly done, that the burden of taxation is thereby increased. The *value* paid by the producers has remained the same; and it is by *values*, and not by *quantities*, that the weight of taxation is always to be measured. If, owing to an improvement in agriculture, in machinery, or any other cause, we could produce *two* quarters of wheat, or *two* yards of cloth, with the *same* expenditure of capital and labour it now takes to produce *one* quarter or *one* yard, it could not certainly be considered as any hardship to have to give *double* the quantity of those commodities in payment of our taxes.

Improvements a Means of enabling a Country to pay additional Taxes.

The want of attention to the principle we have now stated, has led to much erroneous reasoning on the subject of taxation. Even Dr Smith made no sufficient allowance for the effects of improvements, in enabling a country to bear additional taxes. Nothing, however, can be more certain than that the amount of the produce of national industry taken by the Government as revenue, may be regularly increased, in every country in which the arts are progressive, without occasioning any additional burden to the people. Every new invention and discovery, by which the production of commodities can be facilitated, and their value reduced, enables individuals to spare a larger quantity of them for the use of the state. The sacrifice we make in paying taxes really consists in the sacrifice of the labour and expence necessary to procure the money or commodities wherewith to pay them. But every increase in the productive powers of industry, by diminishing the labour and expence required in production, gives us the means of transferring a proportionally greater quantity of commodities to the state, without subjecting ourselves to any additional inconvenience. To pay a given sum of money, or a given value, to Government at this moment, will cost a cotton manufacturer not less, perhaps, than ten or twenty times the *quantity* of cottons that would have been sufficient to make the same payment in 1760: But as this reduction in the value of cottons has been the effect of an equivalent diminution in the expences of their production, the manufacturer is not thereby placed in any respect in a worse situation; nor is he really making

* It was on this occasion that the *taille* was first imposed in France. Hallam's *History of the Middle Ages*, I. p. 118.

General Observations on Taxation.

a greater sacrifice now than he did before. This shows, that Governments have precisely the same interest as their subjects in facilitating production. Every increase of the powers of industry affords the means of putting them in possession of a larger quantity of useful and agreeable products; while every diminution of those powers must either diminish the quantity of produce at their disposal, or force them to lay heavier burdens on their subjects. A rich people is the foundation of a rich treasury. Public wealth is merely a portion of private wealth transferred from individuals to Government; and the greater the wealth of individuals, the greater will be the magnitude of the portion they can conveniently spare for public purposes.

Taxes fall either on Revenue or Capital.

Though taxation be necessary, it ought always to be kept within the narrowest limits possible. All taxes occasion inconvenience and privations. The best are those which are lightest; but there are none so light as not to be productive either of an increase of toil, or of a diminution of enjoyments, or of fortune. All taxes must ultimately fall either on the *revenue* of a country, or on its *capital* or stock. Perhaps there is no one tax whose produce has not been partly derived from the one of these funds, and partly from the other. There can be no doubt, however, that by far the largest proportion of all taxes judiciously imposed, and not carried to too great a height, is paid out of revenue. The desire which every one has to preserve his place in society, stimulates most people to exert themselves to defray their taxes, either by increased industry, or by making a corresponding diminution in their expenditure, without allowing them to encroach on their capitals. But the power to make increased exertions, and to save from expence, though not easily defined, is not illimitable. Every fresh increase of taxation must obviously contribute to its exhaustion: and whenever this has been effected, whenever the burden of taxation is not fully compensated by increased production, or increased saving, *it must* encroach on the means of future production, and the country will begin to retrograde. Taxation, when carried to this extent, is one of the severest scourges to which any people can be subjected. By diminishing capital, or the funds destined to support productive industry, it lessens the *revenue* of the people, the only fund out of which taxes can be permanently paid; and thus lays the sure foundation of national poverty and disgrace, in the destruction of individual fortunes. Like falling bodies, which are precipitated with a constantly and rapidly increasing velocity, a system of taxation acting on capital multiplies pauperism and distress in a geometrical proportion, and destroys alike the desire and the means to reproduce.

It would, however, be an error to suppose, that a tax is necessarily a tax on capital, because it is laid on capital, or a tax on income, because it is laid on income. A moderate tax laid on capital may be, and generally is, defrayed out of a saving of income; while an oppressive tax laid on income has in most cases to be paid from capital. But of all species of taxes, those are plainly the most injurious which necessarily fall on capital, without giving the contributors an opportunity to defray them from revenue. Every such tax, by diminishing the funds for the maintenance of labour, must in so far diminish the future taxable income of the country. The legacy-duty is, as we shall afterwards show, chiefly censurable on this ground.

Different Effects of Moderate and Heavy Taxes.

Most of the writers on finance, patronized by the Governments of the different European countries, have laboured to show that taxation is never a cause of diminished production; but that, on the contrary, every new tax creates a new ability in the subject to bear it, and that every increase of the public burdens becomes the *cause* of a proportional increase in the industry of the people. The fallacy and absurdity of this opinion has been ably exposed by Mr Hume in his *Essay on Taxes*. It is indeed true, as we have already stated, that the desire to preserve their capitals unimpaired, and to improve their condition, will stimulate most men to endeavour to discharge the burden of a moderate tax, by an increase of labour and exertion, or by a saving in articles of unproductive expenditure, without allowing it to encroach on their capitals, or even to lessen the rate at which they may have been previously increasing them. But although this holds good in the case of *moderate* taxes, we are not to conclude from thence that t continues to hold good to whatever extent they may be carried! An individual might be able to defray a tax of L. 50, by increased exertion and economy, while it might be utterly impossible for him to defray a tax of twice or three times that amount without sacrificing a portion of his capital. The truth is, that the effect of exorbitant taxes is not to stimulate industry, but to destroy it. No man will ever be really and perseveringly industrious, whose industry does not yield him a visible increase of comforts and enjoyments. If taxation be carried so high as to swallow the whole, or even the greater part, of the produce of industry above what is required to furnish us with more necessaries, it must, by destroying the hope and the means of rising in the world, take away the most powerful motive to industry and frugality, and, instead of producing increased exertion, will produce only *despair*. The stimulus given by excessive taxation to industry has been not unaptly compared to the stimulus given by the lash to the labour of the *slave*—a stimulus which the experience of all ages and nations has proved to be as ineffective as it is inhuman, when compared to that which the expectation of improving his condition, and of enjoying the fruits of his industry without molestation, gives to the productive energies of the moderately taxed citizen of a free state.

Effect of Heavy Taxes in Spain.

It would be easy to illustrate the effects of oppressive taxation in destroying industry, by references to the History of most European nations.* In

* For an instructive account of the effect of heavy taxes on the commerce and industry of Holland, see the second volume of the excellent work of M. Luzac, *De la Richesse de la Hollande*.

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Spain they have been particularly fatal. The decline of that country has been commonly ascribed to the expulsion of the Jews and Moors, and to the emigrations to America. But had the policy of the Spanish Government been otherwise sufficiently liberal—had industry been properly protected, and moderate and equal taxes levied, the losses occasioned by the expulsion of so many of her most industrious citizens would have been gradually repaired, and the emigration to America would have acted only as a stimulus to population. But oppressive taxes have not only prevented Spain from recovering from the wounds inflicted on her by the bigotry of her rulers, but have gone far to extinguish the very spirit of industry. Of the taxes most instrumental in producing this effect, the *alcavala* is justly entitled to the pre-eminence. The *alcavala* is a tax originally of *ten*, but subsequently of fourteen *per cent.*, charged on all commodities, whether raw or manufactured, as often as they are sold, and rated always according to their selling price. Such a monstrous impost was of itself sufficient to annihilate all industry. The manufactures of Castile and the other provinces subjected to its destroying influence were irretrievably ruined. And Ustariz, Ulloa, and Campomanes, Spanish authors of the highest credit, agree in opinion with Mr Townsend, that it is to their exemption from this odious tax that the comparatively flourishing state of industry in Catalonia and Valencia is entirely to be ascribed.

Taxes do not revert to the Contributors.

Besides contending that the effect of taxes is to create a new ability in the people to bear them, the Government financiers have also contended that the value of the taxes is not really lost to the consumers, but that it is again restored to them by the expenditure of Government and its agents! And notwithstanding the gross and almost obvious fallacy which this statement involves, it still forms the substance of the answers most commonly made to those who complain of the injurious effects of heavy taxes. To show its absurdity, let us suppose that a farmer is taxed to the extent of L. 50, and let us endeavour to ascertain whether the expenditure of this sum by the public functionary, or individual to whom it has been paid by the tax-gatherer, affords any compensation to the farmer for its loss. If the receiver of the tax does not lay it out on commodities produced by the farmer, it is obvious it cannot again return to him, and he can derive no advantage whatever from its expenditure. But let us suppose, which is the most favourable hypothesis for the argument we are combating, that the tax receiver comes to the farmer to buy produce from him, and let us trace the successive steps and effect of the whole transaction. First of all, then, the farmer sold as much corn, or other produce, as was worth L.50; he next paid away these L. 50 to a tax-gatherer; and the person who received the L.50 from the tax-gatherer now comes to the farmer and offers them back to him, on condition of his receiving an *equivalent* in corn or other produce. This is the way in which the money drawn from the pockets of the public by taxation always reverts to them; and if it enriches any one, it is obvious it must do so by making him pay *twice* for the same sum of money! It is to no purpose to endeavour to escape from this *reductio ad absurdum*, by telling us that industry is always benefited by every extension of the market, and that the consumption of soldiers and sailors is advantageous, because it increases demand! To benefit industry a market must be a *real*, not a *nominal* one—it must be one in which the demanders have themselves produced the equivalents they offer for commodities. It is plainly absurd to suppose that either individuals or states can ever receive the smallest benefit from the demand of those whom they have been previously obliged to furnish with the means of buying. Such, however, is always the case with the demand of those who live on the produce of taxation; and to keep up useless regiments and overgrown establishments, on pretence of encouraging and stimulating industry by increasing demand, is to the full as inconsequential and irrational, as if a shopkeeper were to attempt to increase his business and get rich, by furnishing his customers with money to buy his goods.

The fallacy of the doctrine against which we have been contending has been forcibly illustrated by Dr Hamilton. "To argue," says he, "that the money raised in taxes being spent among those who pay it, is, therefore, no loss to them, is no less absurd than the defence of a housebreaker, who, being convicted of carrying off a merchant's money, should plead that he did him no injury, for the money would be returned to him in the purchase of the commodities in which he dealt." *

It is obvious, therefore, that the services rendered by the public functionaries, or by those who receive taxes, form the only compensation given by them to those who pay them. And when neither the number nor the salary of those functionaries is too great, these services are a sufficient return for the sums they receive. But every shilling that is drawn from the people by means of taxes, to be expended in maintaining unnecessary functionaries, or in paying them higher salaries than would suffice to procure the services of others, is absolutely and totally lost to them—as much so as if it were *thrown into the sea or the fire*.

That security, protection, and good government, which it is the object of taxation to procure, are highly valuable, cannot be disputed. But they are like all other values—the smaller the sacrifice for which they can be obtained, so much the better. Every means by which the expences of Government can be diminished and taxation reduced, is an advantage to the public precisely of the same kind that a diminution in the cost of procuring any useful or agreeable commodity is to an individual. There is really no mystery whatever in the manner in which Government is supported and taxation operates.

* This sophism is equally well exposed in the *Lettres d'un Citoyen sur les Vingtiemes*, &c. (p. 113), published in 1768.

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Government is not a producer: its expenditure is not defrayed from the produce of its *own* labour, but *from the produce of the labour of its subjects.* And hence it is obvious, that the higher the expences of Government become, the deeper must they encroach on the income or capital of its subjects, and conversely. In other words, all countries are impoverished by an increase of taxation, and enriched by its reduction: and M. Say is perfectly correct when he says, that the best system of finance is to *spend little;* and the best of all taxes, the *least. Le meilleur de tous les plans de finance est de depenser peu, et le meilleur de tous les impôts est le plus petit.*

Erroneous Opinion of Locke and Quesnay with respect to the Incidence of Taxes on the Land.

Various and very discordant opinions have been entertained respecting the ultimate incidence and effect of particular taxes. Mr Locke in England, and M. Quesnay and his followers in France and Italy, contended that all taxes, in whatever manner they might be imposed, fell ultimately on the land. This erroneous opinion proceeded from their supposing the industry employed in the cultivation of the land to be the only really productive species of industry; whereas it is in no respect more productive than the rest. The truth is, that every burden, directly or indirectly, affecting those engaged in the production of any class of commodities, falls ultimately on its consumers. A tax on hats, for example, must raise the price of hats, as a tax upon leather must raise the price of shoes; for, if this were not the case, the profits of the hatter and shoemaker would be reduced below the general level; and as there can be no reason why they should be satisfied with a lower rate of profits than their neighbours, they would begin to withdraw their capital from such losing businesses, and would continue to do so until the diminution of the supply of their particular commodities had raised their prices to their proper height, or to such a height as would yield them the average profits of stock exclusive of the tax. There are natural limits, however, to the extent to which taxes on commodities can be carried; and their effects are widely different according as they are laid on commodities required for the consumption of the labouring class, or on those which are exclusively consumed by the higher classes. But before proceeding to examine the effects of particular taxes, we shall make a few observations on the following maxims laid down by Dr Smith with regard to all taxes, and which are drawn up with singular judgment and comprehension, viz:—

Dr Smith's Maxims.

First maxim. " The subjects of every state ought to contribute towards the support of the government, as nearly as possible, in proportion to their respective abilities; that is, *in proportion to the revenue which they respectively enjoy under the protection of the state.* The expence of Government to the individuals of a great nation is like the expence of management to the joint tenants of a great estate. In the observation or neglect of this maxim consists what is called the equality or inequality of taxation."

Second, " The tax which each individual is bound to pay ought to be certain, and not arbitrary. The *time* of payment, the *manner* of payment, the *quantity* to be paid, ought all to be clear and plain to the contributor and to every other person. When it is otherwise, every person subject to the tax is put, more or less, in the power of the tax-gatherer, who can either aggravate the tax upon any obnoxious contributor, or extort, by the terror of such aggravation, some present or perquisite to himself. The uncertainty of taxation encourages the insolence and favours the corruption of an order of men who are naturally unpopular, even where they are neither insolent nor corrupt. The certainty of what each individual ought to pay is, in taxation, of so great importance, that a very considerable degree of inequality, it appears, I believe, from the experience of all nations, is not near so great an evil as a very small degree of uncertainty."

Third, " Every tax ought to be levied at the time and in the manner in which it is most likely to be convenient for the contributor to pay it. A tax upon the rent of land, or of houses, payable at the same term at which rents are usually paid, is levied at the time when it is most likely to be convenient for the contributor to pay, or when he is most likely to have wherewithal to pay. Taxes upon such consumable goods as are articles of luxury are all finally paid by the consumer, and generally in a manner that is very convenient for him. He buys them by little and little, as he has occasion to buy the goods; and as he is at liberty, too, either to buy or not to buy as he pleases, it must be his own fault if he ever suffers any considerable inconveniency from such taxes."

Fourth, " Every tax ought to be so contrived as both to take out and to keep out of the pockets of the people as little as possible, over and above what it brings into the public treasury of the state."—(*Wealth of Nations,* III. p. 255.)

French Taxation inconsistent with the First Maxim.

A system of taxation may be pronounced to be either good or bad, according as it approaches to or recedes from these maxims. For example, the great defect in the system of taxation in France and Spain under the old *regime,* consisted not so much in its magnitude, or in the oppressive manner in which it was collected, as in its *inequality.* Instead of all the citizens contributing to supply the wants of the state in proportion to their respective abilities, those who had the largest fortunes, and who, consequently, derived the greatest advantage from the security and protection afforded by Government, were entirely relieved from the burden of direct taxation. The nobility and clergy, at the same time that they engrossed every situation of power and emolument to themselves, were, as far as possible, exempted from contributing any thing to the support of Government. And it is now no longer a question that the disgust occasioned by this inequality of taxation, the impatience of the feudal privileges of the nobility, and the desire of equal rights, were the leading causes of those revolutions which have made so much havoc amongst the ancient institutions of the Continent.

Taxation of Eastern Countries inconsistent with the Second Maxim.

The system of taxation generally established in Eastern countries has the defect of not corresponding with the second maxim laid down by Dr Smith. The amount of the contribution is fluctuating and arbitrary, not fixed and certain. In despotic coun-

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tries, all the agents of Government are despots in their own peculiar sphere; and although the sum demanded by the Sultan should be defined and ascertained, there are no limits to the extortion and rapacity of his agents. An individual who has paid the tax imposed by the Sultan has no guarantee against being called upon to pay three or four times as much to the Pacha of the province. The security of property is thus completely subverted; and the arbitrary nature of the public burdens is entirely destructive of that spirit of industry which might have supported and extended itself under a far greater weight of equable and well defined taxes.*

Warehousing System agrees with the Third Maxim.

The establishment of the *warehousing* system, or the granting of liberty to the merchant, on payment of a moderate rent, to deposit his imported goods in *public warehouses*, under the King's lock and his own, without his being obliged to pay the duties until he finds it convenient to withdraw them, has powerfully contributed to make a large branch of our taxation correspond very closely to the *third* maxim laid down by Dr Smith; or to cause a large class of duties to be levied at the time and in the manner which is most convenient for the contributor to pay them. Previously to the act of the 43d of George III., establishing the warehousing system, the duties on all goods imported, and which amount to a very large proportion of the public revenue, had either to be paid at the moment of their importation, or a *bond*, with sufficient security for their future payment, had to be given to the revenue officers. The hardship and inconvenience of such a system is obvious. Sureties were very difficult to be obtained, and the merchant, in order to raise funds to pay the duties, was frequently reduced to the ruinous necessity of selling his goods immediately on their arrival, at a time when perhaps the market was already glutted. Neither was this the only injury entailed on the country by this system; for the duties having to be paid *all at once*, and not by degrees, as the goods were sold for consumption, their price was raised by the amount of the profit on the capital advanced in payment of the duties; competition, too, was diminished in consequence of the greater command of funds required to carry on trade under such disadvantages; and a few rich individuals were thus, in a great measure, enabled to monopolize the business of importing those commodities on which heavy duties were payable. The system had, besides, an obvious tendency to discourage the carrying trade of the country, and to endanger the security of the revenue. For the necessity of paying import duties even on those commodities which were destined for re-exportation, deprived us of all chance of ever becoming considerable as an *entrepot;* by preventing the importation of almost all foreign commodities, except those colonial products of which we had a monopoly, that were not likely to be speedily required for home consumption; at the same time that the difficulties attending the granting of a really equivalent drawback to the exporters of such as had paid the duty, opened a door for the commission of every species of fraud.

Sir R. Walpole's Excise Scheme.

Sir Robert Walpole appears to have had a very clear conception of the injurious consequences of this system; and it was the object of the famous *Excise Scheme*, proposed by him in 1733, to allow the importers of tobacco and wine to deposit them in public warehouses, and to relieve them from the necessity of paying the duties chargeable on such commodities until they chose to withdraw them for home consumption. The celebrity of this scheme, and the misconceptions that have been so very generally entertained respecting it, incline us to think that we shall only be gratifying our readers by quoting the following passages from the speech made by Sir Robert on submitting his plan to the consideration of the House of Commons.

"The duties now payable upon tobacco, on importation," said Sir Robert, "amount to 6d. and one-third part of a penny *per* pound weight; all which must be paid down in ready money upon importation, with the allowance of ten *per cent.* upon prompt payment; or otherwise there must be bonds given, with sufficient sureties, for the payment thereof; which is often a great loss to the public, and is always a great inconvenience to the merchant importer. Whereas, by what I am to propose, the whole duties to be paid for the future will amount to no more than 4d. and three farthings *per* pound weight; *and this duty not to be paid till the tobacco comes to be sold for home consumption. So that, if the merchant exports his tobacco, he will be quite free from all payment of duty*, or giving bond therefor, or finding out proper sureties for joining in such bond: he will have nothing to do but unload his tobacco on board a ship for exportation, without being at the trouble to attend for having his bonds cancelled, or for taking out debentures for the drawbacks; all which, I conceive, must be a great ease to the fair trader; and to every such trader, the preventing of frauds must be a great advantage, because it will put all the tobacco traders in Britain upon the same footing; which is but just and equal, and what ought certainly to be accomplished, if it be possible.

"Now, in order to make this ease effectual to the fair trader, and to contribute to his advantage by preventing as much as possible any frauds in time to come, I propose, as I have said, to join the laws of excise to those of the customs, and to leave the one penny, or rather three farthings, *per* pound, called the further subsidy, to be still charged at the custom-house upon the importation of any tobacco; which three farthings shall be payable to his Majesty's civil list as heretofore. And I propose, that all tobacco, for the future, after being weighed at the custom-house, and charged with the said three farthings *per* pound, shall be lodged in a warehouse or warehouses, to be appointed by the commissioners of the excise for that purpose, of which

* For an excellent account of the effects of the arbitrary nature of Eastern taxation, see Volney, *Voyage en Syrie*, Tom. II. cap. 33, and cap. 37.

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warehouse the merchant importer shall have one lock and key, and the warehouse-keeper to be appointed by the said commissioners shall have another, in order that the tobacco may lie safe in that warehouse till the merchant finds a market for it, either for exportation or home-consumption. And if his market be for exportation, he may apply to his warehouse-keeper, and take out as much for that purpose as he has occasion for, which, when weighed at the custom-house, shall be discharged of the three farthings *per* pound with which it was charged upon importation; so that the merchant may then export it without any farther trouble. But if his market be for home-consumption, that he shall then pay the three farthings charged upon it at the custom-house upon importation; and that then, upon calling his warehouse-keeper, he may deliver it to the buyer, on paying an inland duty of 4d. *per* pound weight to the proper officer appointed to receive the same."

Sir Robert concluded his speech by saying, "I look upon this as a most innocent scheme; it can be hurtful to none but smugglers and unfair traders. I am certain it will be of great benefit to the revenue, and will tend to make LONDON A FREE PORT, AND, BY CONSEQUENCE, THE MARKET OF THE WORLD. If I had thought otherwise of it, I should never have ventured to propose it in this place." *

Nothing can be more clear and explicit than this statement; and no doubt can now remain in the mind of any one, that the adoption of the scheme would have been of the greatest advantage to the commerce and revenue of the country. But such and so powerful was the delusion generated in the public mind with respect to it, that its proposal had well nigh caused a rebellion. Most of the merchants of the day had availed themselves of the facilities which the existing system afforded of defrauding the revenue; and they dexterously endeavoured to thwart the success of a scheme which would have given a serious check to such practices, by making the public believe that it would be fatal to the commercial prosperity of the country. The efforts of the merchants were powerfully assisted by the spirit of party, which then ran very high. The political opponents of the ministry, anxious for an opportunity to prejudice them in the public estimation, contended that the scheme was only the first step towards the introduction of such an universal system of excise, as would inevitably prove alike subversive of the comfort and liberty of the subject! In consequence of these artful misrepresentations, the most violent clamours were everywhere excited against the scheme. On one occasion the minister narrowly escaped falling a sacrifice to the ungovernable fury of the mob, which beset all the avenues to the House of Commons: and after many violent and lengthened debates, the scheme was ultimately abandoned.

The disadvantages of the old plan, and the benefits to be derived from the establishment of the warehousing system, were very clearly and forcibly stated by Dean Tucker in his *Essay on the Comparative Advantages and Disadvantages of Great Britain and France with respect to Trade*; published in 1750. But so powerful was the impression made by the violent opposition to Sir Robert Walpole's scheme, and such is the force of habit and ignorant prejudice, that it was not until 1803 that this obvious and signal improvement—the greatest, perhaps, that has been made in the financial and commercial system of the country—was adopted.

Expence of collecting Taxes.

The comparative facility and cheapness with which taxes can be collected, ought to be particularly attended to in their imposition. Every tax should, as Dr Smith has stated in his fourth maxim, be contrived so as to take out, and keep out, of the pockets of the people as little as possible above what it puts into the public treasury. The principle of this maxim is obvious—it is the nett produce of taxation, or the sum which it yields after the expences of collection are deducted, that is alone applicable to national purposes; and to impose taxes which it costs a great deal to collect, is to impose a heavy burden on the people for the sake of a small advantage to Government. It is stated by Sully, in his *Memoirs*, as an unquestionable fact, that the expence of collecting a nett revenue of *thirty* millions of livres in France in 1598, cost the enormous sum of 120 millions; or, in other words, that of a sum of 150 millions taken from the people by means of taxation, only *thirty* millions found their way into the coffers of the treasury! Under the administration of M. Necker, a revenue of about 557 millions of livres was collected at an expence of 58 millions; being about $10\frac{2}{3}$ *per cent.*

The expence of collecting the public revenue of Great Britain, for the year ended the 5th January 1822, amounted to L. 6, 6s. 7d. *per cent.* on the nett produce; while in Ireland its expence for the same year amounted to L. 22, 2s. 9d. *per cent.* or to more than three times as much as in England. A good deal of this difference of expence must be ascribed to the different situation of the two countries; but a good deal is also owing to the more defective system of taxation established in Ireland, and to the greater corruption of the officers. The difference in the cost of collecting the Post-office revenue of the two countries is the most extraordinary. In Britain the nett produce for the year ended 5th January 1822 was collected at an expence of L. 38, 18s. 10d. *per cent.*; while in Ireland it cost L. 148, 4s. 10d. *per cent.*! The adoption of the plans and suggestions of the commissioners appointed to inquire into the state of Irish revenue, will undoubtedly be productive of a great saving in the expence of its collection.

Taxes may be collected by officers employed by

* Tindal's *Continuation of Rapin*, VIII. p. 154. ed. 1769; Coxe's *Sir R. Walpole*, I. p. 372, 4to ed. Had the resolutions with respect to tobacco been carried, those regarding wine, which were to have been exactly similar, would have been proposed.

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Mode of Collecting Taxes.

Government to receive them directly from the contributors; or Government may let them *in farm* to individuals for a rent certain, giving to such individuals or their servants the power of collecting them. The question, Which of these modes of collection should be adopted? depends on a variety of circumstances, and does not admit of any general solution. Where a tax is very well defined, and its collection may be effected without requiring any very minute inspection of the private concerns of individuals, it may be almost uniformly farmed with advantage. In such a case the proceedings of the farmers could not excite the prejudices of the contributors; and the greater skill and economy with which all businesses carried on by individuals on their own account are conducted, would enable the farmers to pay, exclusive of the profits made by them, a larger sum to Government on account of the tax, than it would have any chance of receiving from its own agents. But if a tax were not very well defined, or if it required a close examination of the affairs of individuals to assess it fairly, there cannot, we think, be a doubt that it ought to be directly collected by the servants of Government. It is indeed extremely probable that such a tax would be more productive were it farmed; but this, though an important one, is not the only consideration to be attended to. All taxes which occasion any investigation into the private concerns of individuals are necessarily unpopular; and it is obvious that this unpopularity must be immeasurably greater when these investigations are conducted by those who have a direct personal interest in prosecuting them with the greatest strictness, than when they are conducted by the agents of Government—by persons who, in most cases, derive none, and in all cases only a very slender benefit from the increased productiveness of the tax. The mass of the people would most assuredly ascribe much of the hardship of such taxes to the vigilance and keenness of the farmers; and would be disposed to believe that a considerable portion of their produce went into their pockets, and that they were not only assessed to defray the charges of the State, but to add to the fortunes of a class of persons who are universally objects of popular indignation. We admit that these suspicions and complaints are in most cases totally destitute of foundation. The farmers can only enforce payment of a tax according to the provisions in the law imposing it; and if its pressure is either unequal or severe, or the mode of its collection vexatious and troublesome, it is plain the fault lies with those who imposed it, and not with the farmers. But however groundless the public prejudice against the farmers of the revenue may be supposed to be, it is one which will always exist, and ought to be respected. Perhaps we overrate its influence; but really we have very little doubt that, had an income-tax of 5 or 6 *per cent.*, let in farm, been established in the place of the late income-tax of 10 *per cent.*, it would have been generally considered as the most oppressive and vexatious of the two! Although, therefore, we cannot concur with Dr Smith, in his opinion, that *all* taxes ought to be collected by the officers of Government (III. p. 386), neither can we concur with Mr Bentham, who has endeavoured to prove that *farming* is in *every case* the preferable mode of collection. (*Theorie des Peines et des Recompenses*, Tome II. p. 203.) We certainly think that all taxes laid on such articles as stamped paper, houses, windows, horses, carriages, &c., and perhaps also the duties on exportation and importation, might be very advantageously collected by letting them to farmers; but any attempt to farm taxes on income, or taxes which require an examination of and interference with private affairs, would excite the most violent clamour and irritation, and could not be otherwise than pernicious.

Corvées.

The *corvée* system, or the compelling of individuals to execute public works by requisitions of labour, is one of the worst species of taxation. Those who get no pay for their labour, and who are made to work against their will, waste their time and industry: and there is, besides, a very great loss incurred by the interruption of the regular pursuits of the labourers. When Turgot entered on his administration, he sent a circular letter to the Road-surveyors and Engineers of the different provinces of France, ordering them to transmit estimates, framed on the most liberal scale, of the sums of money for which the usual repairs might be made on the old roads, and the ordinary number of new ones constructed. The aggregate of the different estimates showed that a money contribution of about *ten* millions of livres a-year would suffice for the repair and construction of all the roads in the kingdom; whereas Turgot showed, that the execution of these repairs and constructions by contributions of forced labour, or *corvées*, cost not less than *forty* millions, or four times as much as the other! (Say, *Traité d'Economie Politique*, II. p. 345.)

The method of repairing roads, by contributions of labour instead of money, was at one time general throughout Europe, and is still acted on in many countries. In Scotland the agricultural population of the country were compelled, by an act passed in 1669, to work *six* days each year at the public roads. This contribution was denominated statute-labour, and was commuted, in the early part of the reign of his late Majesty, for a tax on land, rated according to its valuation in the cess-books. This commutation has been productive of the greatest advantage. Previously to its taking place, our roads were, perhaps, the very worst, and they have since become among the very best in Europe.

Part II.—Direct Taxes.

Direct Taxes.

It is impossible, for the reasons we have stated in the previous section, to regard such taxes as really fall on capital as a permanent source of public income. Capital consists of that portion of the produce of industry which has been saved from immediate consumption, and which is applied partly to maintain those who are engaged in the great work of production, and partly to facilitate their labours. It is by its amount that the amount of the productive industry of every country must always be regulated. And such being the case, it is plain that whatever has a tendency to diminish capital, or to convert it into revenue, must, by diminishing the means of em-

Taxes on Rent.

ploying and facilitating labour, and consequently the annual produce of the country, be a most fruitful source of pauperism and misery. This, however, would be the precise effect of taxes on capital; and it is for this reason that they ought always to be regarded in the light of an extraordinary resource, and ought never to be imposed except in cases of very urgent necessity. The misapplication and destruction of the means of production which they infallibly occasion, would not only defeat every attempt to render them permanent, but would, by impoverishing and exhausting the country, render all other taxes comparatively unproductive.

It is not from capital, therefore, but from revenue, that all permanent taxes ought to be derived. And the revenue of every individual in every country, who does not subsist on the produce of taxation, being derived either from rent, profit, or wages, it is plain that all taxes which do not fall on capital must, howsoever imposed, ultimately fall on one or other of these three sources. Without further preface, therefore, we shall now proceed to trace the ultimate incidence and effect of such taxes as are laid *directly* on rent, profit, and wages; and when we have ascertained the way in which they operate, it will be comparatively easy to investigate the effect of those direct taxes which are meant to fall equally on all the various sources of income.

Sect. I.—*Taxes on Rent.*

Taxes on Rent.

1. *Taxes on the Rent of Land.*—A tax on the rent of land, properly so called, or on the sum paid by a tenant to a landlord for the use of the *natural and inherent powers of the soil,* would fall wholly on the landlord. Rent is entirely a consequence of the decreasing productiveness of the capital and industry successively applied to the land. If capital could have been always applied to the best soils with *equal* advantage, it is plain no one would ever have thought of resorting to those of an inferior degree of fertility, and no such thing as rent would ever have been heard of. But this is not the case. The best lands in every improving country are speedily exhausted; and it is always found to be more advantageous to lay out capital on the inferior soils, which require a greater expenditure to make them yield the same supplies, than to continue forcing the best lands. Suppose, to illustrate the effect of this constantly operating principle, that a series of soils of various degrees of fertility are in cultivation, and that they respectively yield, in return for the same expenditure of capital, 100, 90, 80, 70, 60, &c. quarters, it is plain, as there cannot be two prices of the same article, at the same time and in the same market; that, when two or more of these soils are cultivated, their produce must all sell for the *same price;* and it is farther plain, that this price must be such as will sufficiently remunerate the cultivators of the worst soil, for otherwise they would not continue to employ their capital in its cultivation. But the price which will remunerate the cultivators of the worst land, will more than remunerate the cultivators of the more fertile lands, precisely in proportion to the greater quantity of produce obtained from them. Now, as there cannot be *two rates of profit* in the same country, any more than two prices, *this excess of produce necessarily constitutes rent.* Thus, when *five* qualities of land are cultivated, the rent of the *first* quality would be 40 quarters; for such is the difference between its produce (100), and the produce (60) of the *fifth* and last quality of land cultivated. In like manner, the rent of the *second* quality would be 30 quarters, or 90—60; the rent of the *third* 20 quarters, or 80—60; and the rent of the *fourth* 10 quarters, or 70—60. But it is obvious no rent would be paid by the cultivators of the soil of the *fifth* quality, and which was last taken into cultivation; nor is it really possible to conceive a case in which rent could enter, for any considerable period, into the cost of that portion of the produce of a country which is raised by the agency of the capital last applied to the soil, whether it be laid out on new land or in the improvement of the old. For, if it did, it would be a proof that agriculture was the best of all businesses, and, in consequence, capital would be immediately attracted to the land, and would most certainly continue flowing in that direction until the produce raised by the portions last employed in cultivation would only yield the common and ordinary rate of profit. It may, therefore, be laid down as a general principle, and one from which there are really no exceptions; that, wherever industry is free, *raw produce is always sold at its necessary price*—that is, at the price which is just sufficient to yield the common and average rate of profit, and no more, to the producers of that portion of the necessary or required supply which is raised in the most unfavourable circumstances, or by means of the capital last laid out on the soil.*

A Tax on Rent, properly so called, would not raise Prices, and would fall entirely on the Landlords.

It results, from this principle, that a tax on rent would have to be entirely defrayed by the landlords. Such a tax would neither raise the price of raw produce, nor operate as a discouragement to cultivation; for, as we have just seen, that that portion of raw produce which regulates the price of all the rest pays no rent, it is impossible it could be affected by its imposition. In fact, all sorts of farm produce would continue at precisely the same price after the tax had been laid on as before, and there would be just the same motives to extend cultivation. In so far, therefore, as the income of the landlords really consists of rent, it might be entirely taken from them by means of direct taxes, without its being possible for them to elude their pressure, and without their occasioning any injury to the other classes of the community. This arises from the circumstance of the landlords not being producers, but only receivers of income. Rent is altogether extrinsic to the cost of production. It really consists of the excess, or of the value of the excess, of the produce

* For a further account of the origin and nature of rent, see the Article Political Economy, Part III. Sect. 3, in this *Supplement.*

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obtained from the best soils, or by the agency of the capital first laid out on the land, over that which is obtained from the worst soils under tillage, or by the agency of the capital last laid out on the land. That the consumers must pay the value of this excess to some one or other is certain; for such payment is one of the absolutely indispensable conditions to their obtaining the necessary supplies of raw produce, and must be made the moment that the increase of population has compelled recourse to be had to inferior soils. But it is plainly of no consequence whatever to them whether they have to pay it to the proprietors of the land, or to a tax-gatherer.

A Tax on that portion of the *gross* Rent of a Farm which consists of Interest of Capital, would raise Prices, and fall on the Consumer.

It must be observed, however, that a tax on rent, in the common acceptation of the word, would not have quite the same effect that we have now stated, and would not wholly fall on the landlord. By rent is commonly meant the whole sum paid by a tenant to a landlord, as well for the use of the buildings, fences, &c. on a farm, as for the use of the natural and inherent powers of the soil. But the sum paid by a tenant for buildings and improvements is not really rent, but interest on the capital expended on them. To whatever extent, therefore, the gross or nominal rent of a farm is made up of interest on capital, to the same extent would a tax on it operate to raise the price of its produce. Suppose, for example, that the gross rent of a farm is L.500, and that L.250 are interest of capital laid out on its improvement. If a tax of 10 *per cent.* were laid on rent, only L.25 would have to be permanently paid by the landlord. The other L.25 might be paid by him for a short period; but, as it would form a deduction from profits, capital would, in consequence, be withdrawn from the soil until the diminished supply of produce had raised prices to their proper level—that is, to such a level as would yield the common and ordinary rate of profit on the capital still employed in cultivation. This part of a tax on gross rent would not, therefore, fall on the landlord, or the farmer, but on the consumer of raw produce.

Effects that would follow from Government reserving to itself the Property of Land.

The circumstance of rent unavoidably arising in the progress of society, inclines us to think that it would be good policy for the governments of countries such as the United States, who are possessed of large tracts of fertile and unappropriated land, to retain the property of this land in their own hands, and to let it by public auction, in such portions, and for such a number of years, as might be deemed advisable. Such a system might perhaps discourage some of those expensive and ostentatious undertakings entered into by individuals who have the absolute property of the lands which they occupy; but there are no grounds whatever for thinking that it would contribute in the smallest degree to prevent any of those improvements which are really conducive to the raising of raw produce. The leases might be made of such a length as to encourage every necessary outlay of capital; and the tenants who had the State for their landlord would certainly run a less risk than those who occupy the estates of individuals of being disturbed in their possession, or of being harassed by vexatious prosecutions. But if no real disadvantage would arise from the adoption of this system, it would be productive of many very great advantages. According as population increased, and as the expences of Government were necessarily augmented, an increasing revenue would be provided to meet them—a revenue, too, it must be recollected—raised without hardship to any individual whatever—and which, even though the Government should not take it, would notwithstanding exist, and have to be paid by the consumers of raw produce. "Under such a system the owners of capital would enjoy its profits; the class of labourers would enjoy their wages, without any deduction whatsoever; and every man would employ his capital in the way which was really most advantageous, without receiving any inducement, by the mischievous operation of a tax, to remove it from a channel in which it was more, to one in which it would be less productive to the nation."—(Mill's *Elements of Political Economy*, p. 199.)

But after land has been appropriated and converted into private property, it would certainly be unjust to lay the burden of supporting the State exclusively on the landlords. Mr Mill is, however, of opinion, that this exemption from exclusive taxation ought only to extend to the present rent, and that the State has a just right to enact that all future increase of rent shall be applied to its use. We cannot assent to this proposition. When an absolute right of property has once been established in land, the owners seem to us to be fairly entitled not only to all the advantages now derivable from it, but to all those of which it may hereafter be made productive. Mr Mill contends, that inasmuch as Government may, by their own act, and without any effort on the part of the landlords, raise rent, there can be no good reason why they should not appropriate to themselves all the excess they have created. But if we establish this principle in one instance, it is difficult to see why it should not be established in others. It is possible for the Government, by repealing the corn laws, and admitting the free importation of raw produce, to raise the profits of stock. But no one would, therefore, contend, that Government would be justified in laying a tax on profits equivalent to the rise that had thus been occasioned; and if not, why should they be justified in laying an exclusive tax on rent when it rises in consequence of any measure of theirs? All classes should be made to contribute, in the same proportion to their means, to the support of the State. But it would certainly be a departure from this just principle to tax those who have acquired a property in land to a greater extent than others, or to give to the State all the advantages they would otherwise have derived from the growing prosperity and improvement of the country.

The greater part of the revenues of the principal monarchies of Asia seems, in all ages, to have been derived from the soil. "The land has been held by the immediate cultivators, generally in small portions, with a perpetual and transferable title; but under an obligation of paying, annually, the government demand, which might be increased at the pleasure of the sovereign, and seldom amounted to less

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than a full rent." (Mill's *Elements of Political Economy*, p. 199.) *

Land-Taxes in England.

The scutages on knights' fees, the assessment of hydage on other lands, and the subsidies chargeable on the proprietors of estates, so often referred to in the history of England, were, to all intents and purposes, land-taxes. (Blackstone, I. p. 312.) But the existing land-tax has supplanted all those more ancient assessments. This tax was first imposed in 1693; a new valuation of all the lands in the kingdom having been made in the previous year. According to this valuation, it was found that a tax of 1s. on the pound of the ascertained rental, afforded an annual clear revenue of L.500,000. No change has ever been made in the valuation of 1692. The tax, which was at first an annual one, has been generally as high as 4s. a pound of the valued rent: In 1798, it was made perpetual at that rate, leave being, at the same time, given to the proprietors to redeem it.

The land-tax was very unequal at its first imposition. For such proprietors as were friendly to the Revolutionary establishment, generally returned their estates at a much higher value than the proprietors who were attached to the Stuarts. The different degrees of improvement that have since taken place in the various districts of the country, have, in some instances, tended to correct the inequalities in the original imposition of the land-tax, and, in others, to increase them.

Taxes on the Rent of Houses.

2. *Taxes on the Rent of Houses.*—The principal part of the rent of houses generally consists of the profits of the capital laid out in their construction, or, as it is more commonly termed, of *building* rent, a comparatively small part only being *ground* rent, or rent payable for the soil on which they are erected. It is evident, therefore, from the principles already established, that, if the supply of houses could be as easily diminished and increased as the supply of raw produce, a tax on their rents would fall entirely on the occupiers and ground landlords, in the proportion that the profits of the capital laid out on them bore to the rent of the land on which they stood. But as the supply of houses is not susceptible of speedy diminution, the builders would have no means of immediately raising rents when a tax was laid on them; and, unless the capital of the country, and, consequently, the population and demand for houses, were rapidly increasing, a considerable number of years would necessarily elapse before they would be able to relieve themselves of the tax. Houses, however, though slowly, are yet certainly perishable; and, as no more of them would be built after they had been taxed, until the increasing demand had raised their rents so as to indemnify the builders for the tax, and to elevate their profits to the common level, there can be no question that, in the end, the tax would be thrown wholly on the occupiers and ground landlords in the proportions already mentioned.

Taxes on Profits.

Sect. II.—*Taxes on Profits.*

Taxes on Profits.

A tax proportioned to the nett profits derived from the capital employed in every branch of industry would fall wholly on profits.

An equal Tax on all Profits would affect all Capitalists to the same extent. It would occasion no rise of Prices, but would fall wholly on Profits.

Such a tax would affect all capitalists to precisely the same extent. When 5 or 10 *per cent.* was laid on the profits of the farmer or manufacturer, an equal 5 or 10 *per cent.* would be laid on the profits of the merchant, the ship-owner, and of all the other employers of capital. It is evident no individual could hope to evade the burden of such a tax by changing his business; and it could not, therefore, occasion any transference of capital from one employment to another. Neither would it occasion any variation in the supply and demand of commodities, nor in their money price. For, as the tax does not fall on capital, but on profits, the means of producing would not be impaired by its imposition; the means of purchasing possessed by those who live on profits, previously to the imposition of the tax, would indeed be diminished; but, as the means of purchasing, possessed by the Government and its agents who receive the tax, would be proportionally augmented, the aggregate demand of the society would continue the same—and hence, as the tax could neither lessen the quantity of capital in the country, nor the power to purchase its produce, it is obvious it could not, supposing the value of money to continue invariable, occasion any variation in the money prices of commodities.

The immediate effect of an equal and universal tax on profits would, therefore, be to sink them in the same proportion. And as the *power* to accumulate capital, and consequently to feed and employ an additional number of people, must ever be in *direct proportion to the rate of profit*, it follows that the tendency, and, when they are carried to such a height as to prevent them being balanced by increased exertion and economy, the ultimate and necessary effect of all such taxes is, to check the accumulation of capital and the progress of population.

A Tax on the Profits of a particular class of Capitalists would raise Prices, and fall on the Consumers.

A tax laid only on the profits of the capital employed in a particular business would have a different effect: it would *raise* prices, and would not, therefore, fall on the capitalists, except in so far as they were themselves consumers of their own produce. Suppose, for example, that a tax of 10 *per cent.* is laid exclusively on the profits of the shoemaker. The slightest consideration will show that such a tax must make an equivalent addition to the price of shoes; for, if it did not, the shoemakers would gain less profit than was gained by those engaged in other businesses, and they would, in consequence, have an immediate inducement to withdraw

* For a full and excellent account of the taxation of Eastern countries, see the same author's *History of India*, Vol. I. chap. Taxes. Some curious and valuable details, with respect to the land-taxes of the ancient Egyptians, may be found in the first volume, liv. i. § 4, of the admirable work of the President De Goguet, *Sur l'Origine des Loix*, &c.

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from their employment; nor can there be a question that they would continue so to withdraw, until, by diminishing the supply of shoes, their price had reached such a height as would yield the common and average rate of profits, exclusive of the tax. For the same reason, an exclusive tax on the profits of the hatter, the clothier, the farmer, &c. would make a proportional addition to the price of hats, cloth, and agricultural produce, &c. In these cases the capitalists have the power to raise prices, and consequently to throw the burden of the tax on the consumers; because they have the power to withdraw from those businesses in which profits are taxed, and to employ their capital in those which are not taxed. But, when the profits arising from the capital employed in every different business are equally taxed, the capitalists are deprived of this resource; and have no means either of raising prices or of evading the tax.

An equal and general Tax on Profits would not affect Rent.

It is easy to see, from the principles we have already established, that a general and equal tax on the profits of agricultural and other capital could not occasion any diminution of rent. When the farmers are taxed equally with all other producers, there will obviously be no motive to induce them to withdraw capital from the land, and no variation will take place in the price of corn; nor, as rent consists in the excess of the produce obtained by the capital first applied to the land over that which is obtained by the capital last applied, will it be affected by such a tax. But if the tax, instead of being a general and equal one, were laid exclusively on the profits of the farmer, it would really cause *an immediate increase of rent*. No rent, as we have shown in the preceding section, ever enters into the cost of producing that portion of the required supply of raw produce raised by the agency of the capital last laid out on the land. It is plainly impossible, therefore, that its raisers could indemnify themselves for any burdens laid on them by making an equivalent deduction from rent. And hence, when a tax is laid exclusively on the profits of agricultural capital, the price of raw produce must sustain a corresponding rise; for in the event of its not rising, the producers of that portion which pays no rent would abandon their business, and the necessary supplies would not be obtained. Inasmuch, however, as the rise of price which is required to remunerate those who raise corn that pays no rent, after a tax is imposed on profits, must be *universal*, it must raise rent. Thus, on our former supposition, that *five* equal capitals applied to soils of various degrees of fertility, respectively yield 100, 90, 80, 70, and 60 quarters, their *corn* rents would be 40, 30, 20, and 10 quarters; and if the price required to remunerate the cultivators of the *fifth* and worst quality of land which pays no rent were L. 4 a quarter, the *money* rent of the *first* quality would be L. 160, of the *second* L. 120, of the *third* L. 80, and so on. Suppose, now, that an exclusive tax is laid on the profits of agricultural capital, and that, to remunerate the cultivators of the worst land, the price rises from L. 4 to L. 4, 10s. a quarter, it is plain the rent of the *first* quality would be immediately raised to L. 180, the second to L. 135, the third to L. 90, and so on; being an increase of L. 20 on the rent of the *first*, of L. 15 on the rent of the *second*, of L. 10 on the *third*, &c.

A Tax on the Profits of the Farmer only would raise Rent.

This is a principle of the highest importance. It shows the unfounded nature of the complaints made by the landlords of the injuries *they* suffer from the operation of taxes on agricultural industry: It shows that such taxes as fall equally on agriculture and on other businesses neither affect rents nor prices, and cannot, therefore, be injurious to the landlords: And it further shows that such taxes as fall exclusively on agricultural profits must, by raising the relative value of corn, raise rents, and materially improve their condition! "That the profits of the farmer," says Mr Ricardo, who was the first to discover and establish this important principle, "only should be taxed, and not the profits of any other capitalist, *would be highly beneficial to the landlords*. It would, in fact, be a tax on the consumers of raw produce, partly for the benefit of the state, and partly for the benefit of the landlords." (*Principles of Political Economy*, 3d edit. p. 241.)

Mode of estimating the Profits of the Farmer under the Income-Tax Act.

In estimating the profits of the farmers under the late income-tax act, it was assumed that in England they amounted, in all cases, to *three-fourths*, and in Scotland to a *half of the rent;* and power was given to the commissioners to make a new valuation of the farm at the end of every seven years during the currency of the lease, and if they found it was then worth a higher rent than was paid by the tenant, his income-tax was proportionally augmented. Many complaints were made against this method of assessing the profits of farmers; and certainly nothing could be more arbitrary and fallacious than the assumed rule for estimating them. But, notwithstanding the general opinion to the contrary, it is not very difficult to discover that the inequalities it occasioned in the collection of the tax were really advantageous to the farmer. The reason is, that while the farmers who occupied rich and well-situated lands, whose rents were comparatively high, were taxed far above their profits, those who occupied poorer lands, the rents of which were comparatively low, were not taxed to the extent of their profits. In these circumstances, the tax had necessarily a two-fold operation: In the first place, its effect was to lower the profits of the capital employed in farming proportionally to *its pressure on those tenants who occupied the worst lands*—for it is by the profits that they make that the profits of all other stock whatever must be regulated: And, in the second place, it had the effect of lowering the rent of the superior lands, by burdening it with all the *excess* of tax falling on the profits of those by whom they were occupied, over that which fell on the profits of the occupiers of the inferior lands. Such was the only way in which, as the tax was actually imposed, the indestructible *level* of profit among the farmers of the various descriptions of land could be preserved. And it is plain, that if the tax had pressed to its full extent on the occupiers of the worst lands in cultivation, it would have made a much greater deduction from the profits of all classes of farmers, at the same time that it would have made no deduction from rent.

The income-tax fell equally on the profits derivable from the other branches of industry as on those

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of the farmer: If his profits had been exclusively taxed, the inequalities in the tax would have been corrected, and the burden thrown off his shoulders to those of the consumers, partly by a *rise* of prices, and partly by a decline of the rents of the best lands.

Account of the *Taille*.

The *taille*, such as it subsisted in France at the epoch of the Revolution, was intended to be a tax on the profits of the farmer. Instead, however, of attempting to estimate these profits by the amount of his rent, or by endeavouring to ascertain the value of the produce remaining in his possession after his rent and other outlays had been deducted, they were commonly estimated by *the amount of the capital employed by him in cultivation*. In consequence of resorting to this criterion for estimating profits, the tax had the effect of inducing the farmer to employ the smallest possible quantity of capital, and of deterring him from making any considerable or expensive improvement. The *taille* was also injurious in another respect; for, as it did not affect the nobles who farmed their own lands, but fell exclusively on those who rented lands of another, or who possessed lands held by a base tenure, it was considered as a degrading tax, and as a mark of the ignoble, or rather servile condition of those by whom it was paid. All who made any thing by farming were thus rendered anxious to withdraw from so degraded a business; while rich merchants and capitalists were prevented from becoming tenants. Not only, therefore, did the *taille* hinder the greater part of the capital generated on the land from being laid out on it, but it turned from it all the capital that had been accumulated in other employments! It is very difficult to suppose that any tax could have been devised better calculated to retain agriculture in a rude and infant state, and to extinguish all emulation and enterprise among the farmers. And considering the long period to which France was subjected to this tax, our wonder is, not that her agriculture was in a very backward and depressed condition at the Revolution, but that it was so far advanced as it really was.*

Contribution fonciere.

The present French land-tax—*contribution fonciere*—equally affects all lands, by whomsoever they may be occupied. It amounts, according to Garnier, to about an *eighth* part of the *net produce* of the land—that is, of its produce, exclusive of the expences of cultivation, but inclusive of rent. Garnier says that the tax is very fairly assessed, and that it is very moderate compared with the various charges with which landed property is burdened in most other countries. It is certainly a very great improvement on the old system. (*Richesse des Nations*, par Garnier, Tome VI. p. 404.)

Sect. III.—*Taxes on Wages.*

Taxes on Wages.

The common and ordinary effect of direct taxes on wages, or on the commodities necessary for the subsistence of the labourer, is to cause a proportional increase of wages and fall of profits.

In every discussion respecting the effect of taxes on wages, or on the necessaries consumed by the labourer, it is of the greatest importance to distinguish between the *natural* or *necessary* rate of wages, or the rate which is required to enable the labourers to exist and continue their race, and the *market* rate, or the rate which they really receive at any particular period.

Natural Price of Labour.

The natural or necessary price of labour, like the natural price of every thing else which is bought and sold, and which may be indefinitely increased or diminished, is determined by the cost of its production. The capacity of the labourer to support himself, and to rear as many children as may be required to keep up the supply of labourers, does not, it is plain, depend on the quantity of money he receives as wages, but on the quantity of food, necessaries, and conveniences essential to his support, for which that money will exchange. The natural rate of wages must, therefore, depend on the cost of producing the food, and other necessaries, required for the maintenance of the labourer. A rise in the market rate of wages does not always coincide with a rise in the price of necessaries; but they can never be very far separated. However high the price of necessaries may rise, the labourers, it is quite clear, must always receive such a quantity as is sufficient to enable them to support themselves and to continue their race. For if wages were to fall below this necessary level, the labourers would be left destitute; there would, in consequence, be a rapid diminution of their numbers; and this diminution would raise wages: and if, on the other hand, they were to rise considerably above it, a proportional stimulus would be given to the principle of population, and the increase of labourers would lower wages.

Agreement of the Market rate of Wages with the Natural rate.

The opinion maintained by those who contend, that the rate of wages does not depend on the cost of producing the articles consumed by the labourers, but on the demand for their exertions compared with their numbers, has obviously originated in their confounding the principles which govern the *market* price of labour, at a particular period, with those which govern its *natural* or *necessary* price. It is undoubtedly true that the market price of labour at any given moment depends on the state of the *supply* as compared with the demand; but it is easy to see that the supply cannot be permanently brought to market unless the rate of wages is such as will suffice to maintain and bring up labourers—that is, unless the *cost of their production be paid*. From whatever point of the political compass we may set out, this is the grand principle to which we must always come at last. Let us suppose, to illustrate this principle, that, owing to a scarcity, the price of the quartern loaf rises to 5s.: It is plain, inasmuch as the same number of labourers would be seeking for employment after the rise as before, and as there is no reason why a scarcity should increase the demand

* For a farther account of the *taille* the reader is referred to Forbonnais, *Recherches sur les Finances de France*, Tome I. p. 107; *Wealth of Nations*, III. p. 303; and to Storch, *Cours d'Economie Politique* (ed. de Say), III. p. 191.

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for labour, that wages would not be advanced; the labourers would, in consequence, be forced to economise, and the rise of price would thus have the effect of lessening consumption, and of distributing the pressure equally throughout the year. But suppose that the rise, instead of being occasioned by a deficient crop, has been occasioned by an increased difficulty of production, and that it will be permanent, the question is, Will wages continue at their former rate, or will they rise? Now, in this case, it is plain that wages must rise: For the comforts of all classes of labourers would be greatly impaired by the rise of prices; and those who, previously to its taking place, had only wherewithal to subsist, would be reduced to a state of extreme destitution, or rather, we should say, of absolute famine. In such circumstances, an increase of *mortality* could hardly fail to take place; while the greater difficulty of providing subsistence would interpose a powerful check to the formation of matrimonial connections and the increase of population. By these means, therefore, either the amount of the population, or the ratio of its increase, or both, would be diminished; and this diminution would continue until the smaller supply of labourers in the market had enabled them to raise wages to their natural rate; that is, as Dr Smith has defined it, to such a rate as would enable them to obtain "not only the commodities which are indispensably necessary for the support of life, but whatever the custom of the country renders it indecent for creditable people, even of the lowest order, to be without."

Variations in the natural rate of Wages.

If a given specific quantity of certain articles were necessary to enable the labourers to exist, it would clearly and directly follow that the rate of wages could not be reduced, for any considerable period, below what would procure them these articles. But there is no such absolute standard of natural wages. It depends essentially on custom and habit. The articles considered as necessaries are perpetually changing. The labourers of Hindostan principally subsist on rice, those of Ireland on potatoes, and those of England on wheaten bread and beef. In one country it is discreditable for the lowest class of labourers to be destitute of comfortable clothing, and of shoes and stockings, while in others shoes and stockings are looked upon as luxuries to be used only by the rich. In many provinces of France and Spain a certain allowance of wine is considered indispensable to existence; and in England the labouring class entertain nearly the same opinion with respect to beer and porter. Nor have the habits of the people, and the standard by which the natural rate of wages has been regulated at different periods in the same countries, been less fluctuating and various. The articles which custom and habit have rendered necessary for the comfortable subsistence of the English and Scottish labourers of the present day are as widely different from those which were judged necessaries by their ancestors, in the reigns of Elizabeth, James I., and Charles I., as they are from those which form the ordinary subsistence of the labourers of France and Spain. The standard of natural wages has been raised, and the poor have been taught to form much more elevated notions respecting the quantity and the species of the articles which it would be disgraceful for them to be without.

Supply of Labour not speedily accommodated to variations in the rate of Wages.

The natural rate of wages is not, therefore, a fixed and unvarying quantity; and though it be strictly true that the market rate of wages can never, when reference is made to periods of average duration, be sunk below its contemporary natural rate, it is no less true that the natural rate has a tendency to rise when the market rate rises, and to fall when it falls. The reason is, that the supply of labour in the market can neither be speedily increased when wages rise, nor speedily diminished when they fall; and it is also on this circumstance that the powerful influence which fluctuations in the market rate of wages have on the condition of the labouring classes principally depends. If the supply of labour could be suddenly increased when wages rise, that rise would be of no advantage whatever to the existing labourers. It would increase their number, but it would not enable them to mount in the scale of society, or to obtain a greater command of the necessaries and conveniences of life. And, on the other hand, if the supply of labour could be suddenly diminished when wages fall, that fall would merely lessen the numbers of labourers, without having any tendency to degrade the habits or to lower the condition of those who survived. But in the actual state of things no rise of wages can ever be counteracted by an increased supply of workmen coming into the market until eighteen or twenty years after it has taken place; for there are few or no branches of industry in which an active and skilful labourer can be bred in a shorter period. During all this interval, therefore, the labourer is placed in a greatly improved situation. He has a greater supply of wholesome and nutritious food; he has better clothes and better habitations; he is rendered more attentive to personal cleanliness; and as he rises higher in the scale of society, he naturally uses more providence and circumspection in the forming of matrimonial connections. In short, his opinions respecting what is necessary for his decent and comfortable subsistence are raised, and the natural rate of wages is in consequence proportionally augmented.

Advantages of a Rise of Wages.

Disadvantages of a Fall of Wages.

But it is equally impossible suddenly to diminish the number of the labourers when wages fall. Such a diminution cannot, as we have already stated, be effected otherwise than by the operation of increased mortality, or by a decrease in the number of births. But unless the fall were very sudden and extensive, it would require a considerable number of years to render the effects of increased mortality very apparent; and it is so difficult to change the habits of a people, that, though the demand for labour were to decline, it would, notwithstanding, continue for a while to flow into the market with nearly the same rapidity as before. Nor would the ratio of the increase of population be sufficiently diminished, until the misery occasioned by the restricted demand on the one hand, and the undiminished supply on the other, had been very generally and widely felt.

Danger of a degradation in the Habits of the Labourers from a Fall of Wages.

In whatever way, therefore, wages may be restored to their natural level when the market rate declines—whether it be by an increase of mortality, or

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a decrease in the number of births, or both—it can never be the work of an instant. It must always require a considerable time before it can be effected; and there is in consequence an obvious risk lest the habits of the labouring class should be degraded in the interim. When wages are considerably reduced the poor are obliged to economise; and should the coarse and scanty fare that is thus, in the first instance, forced upon them by necessity, ultimately become congenial from habit, no check would be given to population, and the *natural rate of wages would be permanently reduced.* In such a case the cost of raising labourers would be diminished; and it is by this cost that the natural rate of wages, with which the market rate must generally correspond, is always regulated. A fall of wages is, therefore, as peculiarly injurious to the labourers as a rise of wages is peculiarly beneficial to them. Its obvious tendency is to sink the natural rate of wages, and to degrade the condition of the largest and not least valuable class in society; and wherever the labourers can bear to retrench, or to descend from a higher to a lower station, it will have this effect, unless their desire to preserve their place in society should occasion a greater prevalence of moral restraint, and a slower increase of population. It is certain, indeed, that to whatever extent wages may fall, the labourers always possess the means of raising them to their former, or to a higher level. If they understock the market with labour, wages will continue high, notwithstanding the means of employment should be diminished; while, if they overstock the market with labour, wages will be low, notwithstanding these means should be very considerably increased. The labourers are thus really in a great measure the arbiters of their own fortune. Nor is there any very great reason to think that their condition will ever be materially improved until they are made acquainted with the circumstances which govern the rate of wages, and are impressed with a full conviction of the important truth, that they are themselves the masters of the only means by which their command over the necessaries and luxuries of life can be really extended.

Taxes on Wages would occasion a corresponding Rise in the Rate.

Dr Smith has said, that, "while the demand for labour and the price of provisions *remain the same,* a direct tax on the wages of labour can have no other effect than to raise them somewhat higher than the tax." (III. p. 323.) It is plain, however, from the principles we have just laid down, that in the event of the demand for labour continuing the same after the tax had been imposed as before, the rise of wages could only be gradually effected; and it would, in consequence, depend entirely on the circumstance of the opinions and habits of the people undergoing no degradation during the period of the rise taking place, whether wages would regain their former elevation. But Mr Ricardo has shown that, in the great majority of cases, the demand for labour would not, as Dr Smith has supposed, continue the same after the imposition of the tax. Suppose, for the sake of illustration, that Government lays a direct tax on wages; as no part of this tax is taken from the capital of the masters, it is obvious it cannot lessen *their* means of employing labour; and it is equally obvious that it must make an equivalent addition to the means of employing labour, or of purchasing the produce of labour, possessed by the Government or its agents who have received the tax. As soon, therefore, as these increased means are brought into market, the greater competition will infallibly raise wages, so as to place the labourers in their previous condition.

This is the way in which taxes are generally expended. But if we suppose that the produce of the tax, instead of being laid out at home, had been remitted as a subsidy to a foreign state, the demand for labour would not be increased in consequence of the competition of Government, and wages could only be raised by slow degrees in the way we have previously described. In all those cases, however, in which the produce either of direct or indirect taxes on wages is laid out at home, they never fail to occasion an equal and immediate rise of wages. The agents of Government then enter the market for labour with means of purchasing which have not been derived from the capitalists, but from the labourers themselves, and wages are thus necessarily raised precisely in proportion to these additional means; or, in other words, to the amount of the tax. Although, therefore, Dr Smith failed in demonstrating his proposition, that a direct tax on the wages of labour is never defrayed by the labourer, the proposition is, nevertheless, strictly true in all those cases in which the tax is laid out at home; and it is also true in those cases in which it is sent abroad as a subsidy, provided the habits of the people and their opinions, respecting what is necessary for their comfortable subsistence, undergo no change after the tax is imposed.

Taxes on Wages really fall on Profits.

We have already shown that every rise of wages must necessarily occasion a corresponding fall in the rate of profit.* It is, therefore, really the same to the capitalists whether a tax on labour, which is to be spent at home, be laid directly on profits or on wages. The capitalists must defray it either at first or second hand. And hence it is that the real injury which such taxes inflict on the labourer does not consist in their immediate but in their remote effects. By falling on profits, their direct tendency is to diminish the power to accumulate capital; and when carried so far as to have this effect, they must, unless the stimulus previously given to population be at the same time diminished by the more powerful operation of the principle of moral restraint, depress the condition of the labourers, and lower the natural rate of wages.

It must, however, be observed, that this is not an effect peculiar to a tax laid directly on profits or wages, but to every tax which is not defrayed either from rent or from a duty on exported goods. Labourers cannot, in any circumstances, be made to

* Art. Political Economy, Part III. § 5, in this *Supplement.*

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contribute considerably to the wants of the state; and if they were sufficiently alive to their own interests, and made a proper use of the power which they possess of regulating the quantity of labour in the market, no tax, even though the produce were remitted to a foreign country, could ever occasion any permanent reduction of the natural rate of wages. It is from profits and rent, therefore, that almost all taxes must be derived. And it is not really of much importance, provided the sum demanded of a capitalist be ascertained, whether he is made to pay it by a direct tax or by taxes on expenditure. If L. 500, for example, be his fair proportion of the revenue required by the state, "the virtue of taxation consists in making sure that he shall pay this sum, neither more nor less." (Ricardo's *Principles*, &c. p. 183, 3d edit.)

Effect of Taxes on Profits and Expenditure in forcing Capital and Individuals abroad.

It is alleged, however, and the allegation is undoubtedly true, that, when the rate of profit, in a particular country, is as low, or but very little higher than the rate of profit among the countries in the vicinity, a heavy direct tax on profits or wages would, by reducing the rate of profit below the common level, have a powerful tendency to cause the transfer of capital to other countries, whereas heavy taxes on expenditure merely occasion the emigration of individuals or families, without prompting them to take their stock along with them. But, although it cannot be doubted that an efflux of capital is much more injurious than an emigration of individuals, still, as the emigrants would thereby avoid taxes laid on expenditure, it is obvious, that if no taxes were laid directly on profits and rents, they would escape taxation altogether, and a disproportionally heavy burden would, in consequence, be thrown on those who continued to reside at home. The truth is, that it is quite impossible to carry either direct or indirect taxes beyond moderate limits, without encountering difficulties. Inasmuch, however, as *equality* of pressure is one of the very highest recommendations of a system of taxation, and *inequality* of pressure one of its greatest defects, the objection to such direct taxes as can be fairly assessed, that they tend to force capital abroad, ought not to be held as conclusive. So long as an individual derives a revenue from capital, so long ought that revenue be made to contribute, in the same proportion as the rest, to the supply of the wants of the country in which the capital is employed. If you cannot draw the L. 500 of taxes, which a capitalist ought to pay, from him, by means of duties on wines, horses, or coaches, or any other article of expenditure, you ought certainly to resort to direct taxation: For, if you do not, this capitalist will not furnish his proper quota of the public revenue, and other individuals will have to pay the portion not paid by him. To prevent taxes on profits or expenditure from forcing either capital or individuals abroad, the only way is to keep them as low as possible. In this respect, as in most others, there is no difference between the expenditure of a state and that of a family. And in both it will be found, as Cicero long ago observed, that *Optimum, et in privatis familiis, et in respublica vectigal est,* PARSIMONIAM.

Having thus endeavoured to trace and exhibit the effects that would result from the imposition of taxes separately affecting rent, profits, and wages; we shall now proceed briefly to inquire into the effects that would result from the imposition of a tax proportioned to the income of each individual.

Taxes on Wages.

SECT. IV.—*Taxes on Income.*

Taxes on Income.

As all income must either be derived from rent, profit, or wages, the effects of a tax on income would necessarily vary according as the incomes of the contributors were derived from one or other of these sources. In so far as income is derived from rent, a tax on it would be really a tax on rent, and would fall wholly on the landlords; and in so far as income is derived from profits, a tax on it would be really a tax on profits, and would fall wholly on the capitalists: But such would not be the case with a tax laid on that part of the income of a country which consists of wages; for, we have already shown, that when the produce of a tax on wages is laid out at home, it causes them to rise to an equal extent; and is, therefore, really the same in its effects as if a tax calculated to raise the same sum were laid directly on profits; and that, when the produce of the tax is remitted abroad, the same rise is brought about, though not so immediately, by the operation of increased mortality, or by a diminished increase of population.

No injustice done to Professional Men by Taxing their Incomes to the same extent as those of Landlords and Capitalists.

By tracing the effects of this principle, we discern the fallacy of the objection to an income-tax, on account of its pressing with equal severity on all incomes, *from whatever sources they may be derived.* There is certainly a great appearance of truth in the statement of those who affirm that it is a monstrous hardship and injustice to make the same deduction from the income of a lawyer or a physician, on whose exertions a numerous family may perhaps be dependent, as from the rent of a landlord or the profit of a capitalist. But if it can be shown that the condition of professional men must be affected by every tax laid exclusively on the incomes of landlords and capitalists, exactly to the same extent as if it had been extended to them, these objections must obviously fall to the ground, and there can be neither hardship nor injustice in making the tax universal. Now it is not very difficult to demonstrate that this would really be the case; and that, in point of fact, it is altogether immaterial to professional men whether, when a tax is laid on income, they pay their full share, or obtain a total exemption.

The revenue or wages of professional men depends partly on the expence necessarily incurred in their education, and partly on the peculiar habits of the society in which they live, and the station they must support. If their wages amounted only to a bare compensation for the expences of education, it is easy to see they could not be permanently affected by a tax on income; for, as soon as the tax was imposed, their wages would become insufficient for their remuneration, and while young men would thus be deterred from entering on professional pursuits, those already engaged in them would have a powerful temptation to withdraw; nor would this double operation cease, until it had, by diminishing the supply, raised the wages of those who remained to their proper level;—that is, until it

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had increased them by the whole amount of the tax. It is clear, therefore, that no lasting or real injury could be done to those professional men, whose earnings are proportioned to the necessary expences of their education, by subjecting them to a tax on income.

It may be supposed, however, that the effect would be different in the case of those whose incomes are not regulated so much by the expence of their education, as by the expence of maintaining themselves in the station in which custom and the habits of society require they should live. But this circumstance does not really make the slightest difference on the result. The situation of professional men must always bear some certain relation to the situation of those among whom they reside. If you either improve or depress the condition of the landlords and capitalists of a country, it will be found to be utterly impossible to maintain professional men in their previous situation. Their interests are inseparably and indissolubly connected with those of the other classes: they must rise when they rise, and they must fall when they fall. Suppose, to illustrate this principle, that a tax is laid on the incomes of landlords and capitalists, from which the incomes of professional men are exempted. It is plain, that the immediate effect of such a tax would be to derange the previously subsisting relations among the different classes and orders of society. The condition of professional men, as compared with that of landlords, farmers, manufacturers, and merchants, would be improved. But this improvement would be of very short duration. For the greater inducements, which the exemption from the tax would hold out to young men to enter on professional pursuits, would not fail to attract additional numbers, until, by the increase of competition, their wages had declined so as to balance the advantage of exemption from the tax, and to place them in the same relative situation as before. If we reverse this hypothesis, and suppose, that, instead of professional incomes being exempted from an income-tax, it is laid exclusively on them, the result will be precisely similar. The situation of professional men, as compared with that of the other classes, would in this case be changed to the worse. There would, in consequence, be a greater disinclination to engage in professional pursuits: and the usual supply of entrants not being obtained, their numbers would be progressively diminished, until the greater competition for their services had again restored them to their proper relative situation; or to the situation they would have occupied, had the tax been levied equally on all classes.

Still, however, it may be said, that though no injustice is done to professional men by taxing them to the same extent as capitalists, when an income-tax forms a *permanent* source of revenue, an injustice would be done them were they taxed to the full extent of the other classes, in the event of its only being imposed during the continuance of a war; because, in such a case, sufficient time would not be afforded to permit the natural principles of adjustment we have described to operate their full effect. But this objection is as untenable as the former. Wars are calamities to which every people must always be liable; and if it were once known that the supplies required to defray their expence were to be raised within the year, by an equal income-tax, the chances of being subjected to this tax would most certainly enter into the calculations of all professional men, and the rate of their natural or necessary wages would be regulated accordingly. In every case, therefore, whether an income-tax is made one of the ordinary sources of revenue, or is only resorted to on extraordinary emergencies, professional incomes ought to be taxed to the same extent as others. To give abatements in their favour, serves only to introduce an apparent inequality into the tax, and to render its collection more difficult, without doing them any real service. If you give them an abatement, their fees will be diminished; and if you do not give it, they will be raised; so that, in either case, they will preserve the same relative situation with respect to the other classes of society.

The only class in whose favour it would be just and equitable to grant an abatement from the full charge on account of an income-tax, are those who derive their incomes from *fixed* and *terminable* annuities. It is obvious, that such a tax would press with greater severity on them than on landlords or capitalists, whose incomes are derived from what may be considered as inexhaustible sources; and it would also press with greater severity on them than on professional men, whose incomes would be augmented in consequence of its imposition; and, therefore, it would be necessary to avoid laying any greater burden on the possessors of *terminable* annuities, than on the other classes; or, to preserve them in the same relative situation, to make an abatement in their favour in an inverse proportion to the duration of their annuities.

If an income-tax were extended to the wages of common labourers, it would not really fall upon them, but on the capitalists who employ them. And it would, therefore, be necessary, in the event of such a tax being imposed, to increase the proportion affecting the rents of the landlords; for otherwise they would be less heavily taxed than the capitalists, who would have to pay the portion which falls on wages.

An Income-tax ought not to increase with the Increase of Incomes.

It has been urged by M. Say, and other able economists, that an income-tax ought not to bear the *same* relation to all incomes. A tax of L. 10, for example, is said to be more severely felt by the possessor of an income of L. 100, than a tax of L. 100 or L. 1000, by the possessor of an income of L. 1000 or L. 10,000; and it is contended, that, in order fairly to proportion the tax to the *ability* of the payers, such a *graduated scale* of duties should be adopted, as would press lightly on the smaller incomes, and increase according as they became larger, and more able to bear taxation. We cannot, however, concur with those who hold this opinion. It is surely no part of the business of Government to impose taxes, in the view of regulating the incomes of the contributors, or for the purpose of depressing one class and elevating another. *Every just tax will leave individuals in the same relative situation in which it found them;* and it cannot do this otherwise, than by taking the *same proportion* of their incomes from each. That such a tax will be more acutely

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felt by the poorer than by the wealthier classes is undeniable; but the same thing is true of taxes on commodities, and of every imposition which does not subvert the already subsisting relations among the different orders of society. The hardship in question is, in fact, *one of the evils of poverty*, and not of equal taxation; and to attempt to alleviate it, by adopting such a graduated scale of duties as has been proposed, would really be to impose taxes on the wealthier part of the community, for the benefit of their less opulent brethren, and not for the sake of the public revenue. The establishment of such a principle would be most mischievous; if carried to its full extent, it would sanction the total exemption of limited incomes from the burden of taxation, until those that were higher had been reduced to the same level; and would thus be subversive of almost every motive to industry and economy.

An Income-tax ought to press equally on Income, without consulting the situation of the Parties.

The objections to an equal income-tax, on the ground of its making "no distinction between the income which has a numerous family to support, and that of the retired bachelor or the unexpensive maiden," * are still more destitute of foundation. In fact, the peculiar excellence of an income-tax consists in its making no such distinction,—in its sweeping, with indiscriminating severity, its equal demands from all. If taxes be not laid on income, they *must* be laid on expenditure; and it is obvious, that while an individual who has an expensive station or a large family to support, must contribute largely to taxes on expenditure, misers and those who have no families may nearly escape them altogether. It has been suggested, that this inequality might be got rid of by making distinctions in the duties on commodities, proportioned to the relative condition of those who buy them; or by enacting, that those who have so many children shall pay a certain duty, and those who have so many more, a different duty. But the extreme complexity of such a plan, and the facilities it would give to every species of fraud and evasion, will always prevent its adoption. Supposing, however, that it could be adopted, it would be, in the highest degree, unjust and inexpedient:—unjust, in as much as a reduction of duties in favour of those who have small incomes, would proportionally depress the wealthier classes, and change the relative situation of individuals; and inexpedient, in as much as a reduction in favour of those who have large families, would act as a stimulus to marriage, which, if it ought not to be discouraged, certainly stands in no need of encouragement. So long, therefore, as taxes affect only expenditure, those who are obliged to spend must unavoidably pay more than their just proportion of the public revenue. But a fairly levied tax on income would obviate this defect, and would make misers, bachelors, and maidens, contribute equally with the other classes to the demands of the state.

The real objection to an Income-tax consists in the difficulty of assessing it fairly and equally.

For these reasons, we have no hesitation in giving it as our decided opinion, *that if a tax on income could be fairly collected*, it would be one of the most impartial and least objectionable taxes that it is possible to impose. It may, however, be laid down as an indisputable axiom, that every tax which affords a great *facility of evasion* is essentially defective; and there are very cogent reasons for thinking that this must always be the case with an income-tax. The income derived from lands, houses, and other fixed property, may be learned without much difficulty; but it has hitherto been found to be quite impossible to ascertain the wages of professional persons, or the profits of the capital engaged in manufacturing and commercial undertakings with any thing like tolerable precision. It is this extreme difficulty of making an equal and impartial assessment, that constitutes the real and only good objection to an income-tax. By setting the interests of the contributors in direct opposition to their duties, and tempting them to conceal and underrate their incomes, it obviously operates as a bounty on perjury and fraud; and, if carried to a very great height, it would undoubtedly generate the most flagrant and barefaced prostitution of principle, and would do much to obliterate that nice sense of honour which is the only sure foundation of national probity and virtue. The discovery of means by which these highly injurious effects might be obviated, and incomes ascertained without the necessity of instituting an odious and generally ineffectual inquisition into the private affairs of individuals, would be the greatest practical improvement which it seems possible to make in the science of taxation. But until such means are devised,—and we are not certainly very sanguine in our expectations on the subject,—an income-tax must, besides its injury to public morals, be partial and unequal in its operation, and ought not, therefore, to be imposed, except in cases when a large revenue must be raised.

Account of the late Income-Tax.

In order to furnish the means of defraying the enormous cost of the war begun in 1793, Mr Pitt proposed, in 1797, to triple the amount of the assessed taxes, or duties on houses, windows, horses, carriages, &c. This plan, however, did not answer the expectations of its projectors, and next year it was abandoned, and a tax on income substituted in its stead. According to the provisions of the act imposing this tax, all incomes of less than L. 60 a year were exempted from assessment; an income of from L. 60 to L. 65 was taxed one *one hundred and twentieth* part; and the rate of duty increased through a variety of gradations, until the income reached L.200, or upwards, when it amounted to a *tenth* part, which was its utmost limit; a variety of deductions being at the same time granted, on account of children, &c. The commissioners to whom the management of this tax was entrusted were chosen by the freeholders of counties, and the electors of burghs, in the same way as their representatives in Parliament, only that a smaller qualification was sufficient to enable any one to be elected a commissioner. The services of the commissioners were gratuitous; and they were sworn to preserve the most inviolable secrecy with respect to the affairs of individuals. They

* Glover *On the Character and Tendency of the Property-Tax. Pamphleteer,* Vol. VIII. p. 563.

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were authorized to call for returns from every person whose income they supposed to exceed L. 60 a year; and in the event of their being dissatisfied with these returns, they were empowered to call for written explanations, and ultimately for the oath of the party. But this examination was rarely necessary, except in the case of incomes derived from wages, from capital employed in manufacturing and commercial business, or from the interest of loans; the rental of landlords being, in most cases, learned from the terms of the leases held by their tenants; and the profits of the tenants being, as we have already observed, estimated at a certain proportion of the rent. The commissioners were assisted, or rather overlooked, by the tax-surveyors appointed by Government, who were required to see the provisions of the act strictly enforced, and whose duty it was to scrutinize all returns of income, to challenge such as they considered fraudulent, to object to the deductions allowed by the ordinary commissioners, and to bring the matter under the review of the commissioners of appeal, whose sentence was final. Notwithstanding the apparent complexity of these regulations, they worked extremely well; and though much fraud and evasion were certainly practised, yet, on the whole, the tax was collected with infinitely less difficulty, and with greater fairness and equality, than could have been rationally anticipated.

This tax was repealed in 1802, after the peace of Amiens, having produced, on an average, about *five millions and a half* annually.

In 1803 the income-tax, under the name of property-tax, was again revived. The assessment began, as before, on incomes so low as L. 60 a year, and gradually increased until the income reached L. 150 a year, when it amounted to 5 *per cent.*, which was its highest rate. An addition was made to this tax in 1805; and in 1806, during the short-lived administration of Mr Fox and Lord Grenville, the assessment was raised to 10 *per cent.* on all incomes, however small, arising from land or capital; professional incomes under L. 50 were exempted from the tax; and incomes of that sort exceeding L. 50, and under L. 150, the limit at which they became subject to the full assessment of 10 *per cent.*, were allowed deductions, varying inversely as their magnitude. A very great outcry was made against the ministers who proposed this addition to the income-tax; but it may safely be affirmed that, in the then situation of the country, it was a highly necessary measure, and one for which they really deserved the thanks of the public. The income-tax was finally repealed in 1816.

We subjoin, from a Parliamentary paper presented to the House of Commons on the 26th February 1823, a return of the total *gross* and *net* assessments to the property or income-tax, for the year ending 5th of April 1815:—

	Gross Assessment.	Net Assessment.
A. Lands, Tenements, Hereditaments, or Heritages	L. 5,923,486 ...	L. 5,923,189
B. Houses, Lands, and Tenements	2,734,451 ...	2,176,228
C. Funded and Stock Properties	2,885,505 ...	2,885,505
D. Profits and Gains of Trade	3,831,088 ...	3,146,332
E. Salaries, Pensions, &c.	1,174,456 ...	1,167,678
Totals	L. 16,548,985	L. 15,298,982

The following is the Return of the Value of the several species of Property on which the Assessment was made for the Years ending 1813 and 1814, ending the 5th April 1814 and 1815, viz.—

Schedules.	1813.	1814.
A.	L. 56,701,923 ...	L. 60,138,330
B.	36,336,883 ...	38,396,144
D.	36,080,167 . .	38,310,935
E.	11,380,748 ...	11,744,557
C. not stated, but estimated at	30,000,000 ...	30,000,000
Totals	L. 170,499,721	L. 178,589,966

Sect. V.—*Poor Rates.*

Poor Rates.

The incidence and effect of poor rates depend on the mode in which they are imposed. If they were laid exclusively on the land, and levied proportionally to its rent, they would be really a tax on rent, and would be wholly defrayed by the landlords. If they were laid exclusively on the rent of houses, they would, in certain circumstances, fall wholly on the occupiers, in others on the builders, and in others on the occupiers and ground landlords; and, if they were laid on profits, they would fall equally on farmers, manufacturers, and merchants, or on capitalists in general. In the actual state of things in this country, we believe that a much larger proportion of the poor rates falls on the farmer than on any one else; and they, consequently, contribute to raise the price of his produce just as any other tax affecting either his crop or the instruments used by him in cultivation. Mr Ricardo has made an allowance for this greater pressure of the poor rates on the farmer in his estimate of the countervailing duty to be laid on foreign corn, to balance the excess of taxes affecting that which is raised at home.

Having thus endeavoured to exhibit the operation, and to trace the ultimate incidence and effect of such taxes as fall *directly* on income, we come now to the second branch of our subject, or to the

Advantages and Disadvantages of Indirect Taxes.

consideration of those taxes which fall *indirectly* on income.

Part III.—Indirect Taxes.

Sect. I.—*Advantages and Disadvantages of Indirect Taxes.*

Reasons recommending the Imposition of Indirect Taxes.

Though most governments have had recourse to direct taxes, they have rarely formed the sole or even principal source of their revenue. Indirect taxes have almost invariably been the greatest favourites both of princes and their subjects; and there are a variety of reasons why this should be the case. The burden of direct taxation is palpable and obvious. It admits of no species of disguise or concealment, but makes every one fully sensible of the exact value of the portion of his income taken from him by government. There is, however, a natural and inherent repugnance in the human breast to part with the produce of industry, except for the purpose of obtaining some more acceptable equivalent in its stead. And as the benefits derived from the institution of government are neither so very obvious nor striking as to be easily and readily felt and appreciated by the great body of the people, there is, in the great majority of cases, an extreme disinclination to pay a large amount of direct taxes. It is for this reason that governments have so generally had recourse to indirect taxes. Instead of exciting the prejudices of their subjects by openly demanding a certain specific portion of their incomes, they have taxed the articles on which these incomes are in general expended! The effect of this ingenious plan is to conceal the amount of taxation, and to make its payment appear in some measure voluntary. The tax being generally paid, in the first instance, by the producers, the purchasers confound it with the natural price of the commodity. No separate demand being made upon them for the tax, it escapes their recollection; and the article they have received seems a full equivalent for the sacrifice they have made in acquiring it.* Such taxes have also the advantage of being paid by degrees, in small portions, and at the time when the commodities are wanted for consumption, or when it is most convenient for the consumers to pay them.

Moderate Indirect Taxes stimulate Industry.

Besides their greater facility of imposition, indirect taxes have been frequently supposed to have the further and exclusive advantage of acting as a stimulus to industry. "Dans la perception, directe," says the Marquis Garnier, "l'impôt se montre sans nul deguisement; il vient sans etre attendu, à cause de l'imprévoyance si ordinaire au commun des hommes, et il apporte toujours avec lui de la gene et du decouragement. Mais l'impôt indirect, en ajoutant successivement un surcroit de prix aux articles de consommation génerale et journalière, au moment ou tous les membres de la société ont contracté l'habitude des ses consommations, rend ses divers articles un peu plus couteux à acquerir, c'est-a-dire, qu'il donne lieu à ce qu'il faille, pour se les procurer, un surcroît proportionné de travail et d'industrie. Or, *si cet impôt est mesuré de manière à ne pas aller jusques à decourager la consommation*, ne semble-t-il pas, dans ce cas, agir comme un stimulant universel sur la partie active et industrieuse de la société, qui l'excite à un redoublement d'efforts, pour n'être pas obligé de renoncer à des jouissances que l'habitude lui a rendues presque nécessaires, et qui, en consequence, donne un plus grand développement aux facultés productives du travail et aux resources de l'industrie? Ne doit-il pas en resulter, qu'aprés l'impôt, il y a la même somme de travail et d'industrie qu'auparavant pour fournir aux besoins et aux jouissances habituelles des hommes qui composent la classe laborieuse, plus la somme de travail et d'industrie qui a dû pourvoir au surcroît de prix destiné à l'impôt? Or, cet impôt, ou ce surcroît de produit que se paye, etant dépensé par le gouvernement qui le recueille, sert à alimenter une nouvelle classe des consommateurs, qui forment des demandes qui l'impôt les met à porté de payer." (*Preface à la Traduction de la Richesse des Nations*, Tome I. p. 66, ed. 2de.)

The truth of the greater part of this statement cannot be disputed. It is, however, essential to observe, that the whole effect ascribed by M. Garnier to indirect taxes, in stimulating industry, depends on the circumstance of their being so moderate as not to discourage consumption; or, which is really the same thing, that they are so moderate *as to give the contributors the power of defraying them by increased exertion and economy*. If this were not the case, they would have a precisely opposite effect, and instead of acting as a stimulus to production, they would certainly occasion its decline. But we can perceive no grounds for supposing that a moderate income-tax would have a different effect on industry from moderate taxes on expenditure. It would most undoubtedly serve as a spur to excite every one to make additional exertions, otherwise he would be unable to preserve his capital unimpaired, and to retain his former command over the necessaries and luxuries of life. Increase of exertion is not an exclusive consequence of indirect taxation; but it is an exclusive consequence of *moderate* taxation, whether it be direct or indirect. Just as a decay of industry, and a general impoverishment, is not the exclusive consequence of any particular species of taxation, but of all taxes whatever, when they are carried to an excessive height.

Disadvantages of Indirect Taxes.

We doubt, therefore, whether the generality of taxes on expenditure possess any real advantage over taxes on income, except in the facility of imposition, while they certainly labour under many very considerable disadvantages. In the *first* place, taxes on commodities necessarily alter the natural distri-

Disturb the natural Distribution of Capital.

* Nero was supposed to have abolished the duty of 4 *per cent.* on the slaves sold in Rome, when he really did no more than order it to be paid by the seller instead of the buyer. "*Remissum*," says Tacitus, "*specie magis quam vi; quia cum venditor pendere juberetur, in partem pretii emptoribus accrescebat.*" *Annal.* lib. 13, cap. 32.

Advantages and Disadvantages of Indirect Taxes.

bution of the capital and industry of the country, and force them into less advantageous channels. They do this, because, when a tax is laid on a particular class of commodities, the producers, in order to raise the price proportionally to the tax, diminish the supply in the market, by transferring a portion of the capital employed in the production of the taxed commodities to some other business. But an equal income-tax would operate as *an equal tax on profits;* and when all profits are equally taxed, no advantage would be gained by transferring capital from one business to another, and the producers would have no means whatever of raising prices. Under the operation of such a tax, every individual would continue, just as he would have done had he not been taxed at all, to employ himself in those businesses which are naturally most advantageous. Capital and industry would not be forced into artificial channels. The pay of troops and of public functionaries would not be raised, because of a rise of prices occasioned by taxation; at the end of a war, every thing would be found in its proper position; there would be no revulsion; and we should be immediately enabled to avail ourselves to the utmost of all our natural and acquired resources.

Raise the price of Commodities to a greater extent than the amount of the Tax.

In the *second* place, taxes on commodities are almost always paid by the producers before they are sold to the consumers, and are frequently, indeed, advanced in an early stage of the manufacture. Their effect is, therefore, not only to increase the price of the commodity, by the whole amount of the duty, but also by the profit due to the manufacturer for the time it has been advanced by him. But it should be observed, that though this circumstance undoubtedly operates to increase prices, its influence in this respect has been greatly over-rated by Sir Matthew Decker, M. Say, and M. Sismondi. The latter has calculated that a tax of 4000 francs, paid originally by a manufacturer, whose profits were 10 *per cent.* would, if the commodity manufactured only passed through the hands of *five* different persons, be raised to the consumer to the sum of 6734 francs! This calculation proceeds on the supposition, that he who first advanced the tax would receive from the next manufacturer 4400 francs, and he, again, from the next 4840 francs; so that at each step 10 *per cent.* on its value should be added to it. "But this," as Mr Ricardo has justly observed, "is to suppose that the value of the tax would be accumulating at *compound* interest; not at the rate of 10 *per cent. per annum*, but at an absolute rate of 10 *per cent.* at every step of its progress. M. Sismondi's statement would be correct, if *five years* elapsed between the first advance of the tax and the sale of the taxed commodity to the consumer; but if one year only elapsed, a remuneration of 400 francs, instead of 2734, would give a profit at the rate of 10 *per cent. per annum,* to all who had contributed to the advance of the tax, whether the commodity had passed through the hands of *five* manufacturers or *fifty*." (*Principles,* &c. 3d edit. p. 459.)

Encourage Smuggling

In the *third* place, duties on commodities encourage smuggling. "They tempt," says Dr Smith, "persons to violate the laws of their country, who are frequently incapable of violating those of natural justice, and who would have been in every respect excellent citizens, had not the laws of their country made that a crime which nature never meant to be so." (III. p. 378.) In consequence of this tendency, duties on commodities require the employment of a great number of revenue officers; and as they expose the producers of the taxed articles to considerable inconvenience and hardship from domiciliary visits, they force them to indemnify themselves by making a corresponding addition to the price of their goods.

Unequal.

But the great objection to taxes on expenditure consists in their inequality. We have already shown that such taxes cannot possibly be rendered equal and impartial in their operation; that they do not affect the different classes of society in proportion to their ability to bear them; and that, while they may be almost wholly evaded by rich misers, and those in unexpensive stations, they press with disproportionate severity on those who have large families and expensive stations to support. At the same time it should be remembered, that in taxation we have only a choice of difficulties. And notwithstanding it does not appear possible to free taxes on expenditure from these very weighty objections, the greater readiness with which they are paid, combined with the extreme difficulty of laying an income-tax equally on rent, profits, and professional wages, will always prevent their abolition. Neither, perhaps, would it be really desirable to take off those duties which affect only luxuries. But without entering on the discussion of this question, we are satisfied that if the difficulties, in the way of a fair income-tax, could be removed, it would be among the least objectionable of any; and if it were not exclusively adopted, it ought at all events to be made one of the *principal* sources of the public income. It is unnecessary, however, after what we have previously stated, to insist farther on this point; and we shall, therefore, proceed to inquire into the effects on their price, of taxes on commodities, and on whom they ultimately fall.

Sect. II.—*Inquiry into the Incidence and Effect of Indirect Taxes.*

Taxes on a particular Commodity.

1. *Taxes on a particular Commodity.*—With regard to the effect of taxes on the price of commodities, it is clear that if a duty be laid on a particular commodity, and not on others, its price will sustain an equal rise; for, if it did not rise to this extent, the profits of the producers would be sunk below the common level, and their business would be abandoned. But it depends on the circumstance of the commodity being of the class denominated *luxuries,* whether a tax on it will fall wholly on the consumers. In so far as *necessaries* are consumed by landlords or capitalists, taxes on them are also defrayed by the consumers; but, in so far as they are required for the consumption of labourers, the effect of taxes on them is in no respect different from the effect of an equal amount of taxes laid directly on wages: And we have already shown that there are very few cases in which taxes affecting wages are really defrayed by the labourers; and that their common and ordinary effect is to cause an immediate

Taxes on Commodities.

and equivalent rise in the rate of wages, and a proportional fall of profits. It appears, therefore, that taxes on necessaries do not wholly fall on the consumers; but that they are partly defrayed by them, and partly also by the proprietors of stock, in consequence of their reducing the rate of profits. Such, however, is never the case with taxes on luxuries, or on commodities used only by the rich. A duty on velvets, on claret, and on coaches, for example, falls immediately on the consumers, and cannot be thrown on any one else. Such articles not being used by labourers, a duty on them can neither raise wages nor affect the rate of profit.

Taxes on all Commodities.

2. *Ad valorem Taxes on all Commodities.*—It is not so easy to trace the effects, on their price, of an equal *ad valorem* duty on *all* commodities. Such a duty could not, it is obvious, at all affect their values relatively to each other; and supposing their quantity and the quantity of money in the country to continue the same, it has been contended that it could occasion no rise of prices. But a very few words will be sufficient to show the fallacy of this statement. The Government must receive the tax either in money or in goods. Now suppose, for the sake of illustration, that the duty is ten *per cent.*, and that it is paid in kind; in this case the supply of produce remaining in the market after the tax is paid being diminished *one-tenth,* the purchasers will only get *nine-tenths* of the commodities they previously got in return for the same quantity of money, or, in other words, prices will rise ten *per cent.* If the Government receives the tax in money, the result will be precisely similar. The purchasers will still have to reimburse the producers for the tax, or to pay them ten *per cent.* additional for their goods. For if this were not really the case—if the purchasers who do not directly pay the tax to Government, continued to get the same quantity of produce for the same sum of money, after its imposition as before, there would be no cause in operation to occasion the smallest diminution of individual consumption; and it is plainly impossible that the tax could, in such circumstances, give the Government the means of obtaining an increased share of the produce of the country, which is absurd. Not only, therefore, is it certain that a tax on a particular class of commodities will raise their price; but it is also certain that an equal *ad valorem* duty on all commodities will, without any increase of money, occasion an equal and universal rise of prices. The real effect of every such tax is to transfer a portion of the produce of the industry of the country into the hands of Government, and consequently to cause a *less* portion of that produce to come into the hands of every individual whose means of purchasing are not increased. Such a rise of prices is widely different from the rise which is occasioned by an increase in the quantity of money. When it is increased prices rise, because *more money* is given for the *same quantity of goods;* but when an *ad valorem* duty is levied, prices rise, because the *same sum of money* is given for a *less quantity of goods,* a portion of them having been transferred to Government.

Taxes on Raw Produce.

3. *Taxes on Raw Produce.*—It has been very generally supposed that the taxes laid on the raw produce of the soil have a different incidence from taxes laid on manufactured commodities; and that, instead of raising prices, and falling on the consumer, they have no influence on prices, and fall wholly on the landlord. We believe, however, that we shall be able to show that this opinion is entirely without foundation; and that the real effect of taxes on raw produce is to cause a proportional rise of prices, and to affect all classes equally in proportion to their respective consumption of the taxed articles.

Tithes.

If land yielded no surplus to its possessors above the common and ordinary profit of the capital employed in its cultivation, it is plain that the imposition of a tax on its produce, a tithe, for example, would occasion an equivalent increase of its price. The level of profit may be temporarily, but it cannot be permanently, elevated or depressed in any particular branch of industry. And as there can be no reason why the agriculturists should content themselves with a reduced rate of profit, when all other employments are yielding a higher rate, as soon as tithes were imposed they would set about transferring a portion of their stock to some more lucrative business; and this transference would be continued until the diminution of supply had raised prices to their proper level, and restored the equilibrium of profit. In such a state of things, tithes would indisputably operate precisely as an equivalent addition to the price of raw produce. But after various qualities of soil have been brought under cultivation, and rents have, in consequence, been pretty generally introduced, it is not so easy to trace their ultimate incidence and effect. They then appear to occasion rather a diminution of the rent of the landlord than a rise of prices. Farms which are tithe-free always bring a proportionally higher rent than such as are subject to that charge; and it is naturally concluded, that, were tithes abolished, the depressed rents would be raised to the same level as the others. For this reason, in an advanced stage of society tithes have not been considered as increasing *the price* of raw produce to the consumers, but as falling on rent, and as diverting a portion of it into the pockets of its rightful owners, the clergymen and lay-impropriators. "Taxes on the produce of land," says Dr Smith, "are in reality taxes upon rent; and, though they may be originally advanced by the farmer, are finally paid by the landlord. When a certain portion of the produce is to be paid away for a tax, the farmer computes as well as he can what the value of this portion, one year with another, is likely to amount to, and *makes a proportional abatement in the rent which he agrees to pay to the landlord.* There is no farmer who does not compute, beforehand, what the church tithe, which is a land-tax of this kind, is, one year with another, likely to amount to." (III. p. 274.)

Dr Smith's Opinion with respect to the Incidence of Tithes.

Error of this Opinion. Tithes and other Taxes on Raw Produce do not fall on the Rent of the Landlord, but on the Consumers of Raw Produce.

That this is the general opinion on the subject cannot be doubted; but notwithstanding the high authority by which it is supported, it is most certainly without foundation. We have shown, in treating of taxes on rent, that in every country that portion of the required supply of raw produce which is raised by the agency of the capital last applied to the soil, and which governs the price of all the rest, never yields any rent but merely the common and average rate of profit to the landlord or the occupier. Now

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this principle is decisive as to the effect of tithes and other taxes on raw produce. If tithes were only levied from the superior soils, they would not, after inferior soils had been cultivated, occasion any rise of price, but would fall entirely on the rent of the landlord. But this is not the case with tithes. They affect *every quality of land indiscriminately*, and being exacted equally from the produce raised in the least favourable, as from that which is raised in the most favourable circumstances, occasion *only an increase of prices*. Suppose no tithes are levied, and that the wheat raised on the *poorest* lands, or with the capital last applied to the soil, and which determines the price of the whole crop, yields a sufficient profit to the cultivator, and no more, when it sells for 70s. a quarter—the price must rise to 77s. before the same profit can be obtained after tithes are imposed. In this case the tithe cannot possibly occasion any diminution of rent; for this produce pays no rent; so that if it were not compensated to the cultivators by an increase of prices, they would withdraw their capital from cultivation, and the necessary supplies would no longer be obtained.

If Tithes were abolished, the Rent of Tithe-free Farms would fall.

This account of tithes is nowise inconsistent with the admitted fact, that farms which are free from this burden bring a proportionally higher rent. The expences attending their cultivation are not increased by the levying a tithe from the produce of other farms; but, as there cannot be *two prices*, their occupiers obtain the same *increased* price for their produce which is necessary to indemnify the cultivators of the tithed lands. There must, however, be *an equality of profits*, as well as of prices; and hence, whatever advantage the occupier of a tithe-free farm may gain by being relieved from a burden to which his neighbours are subjected, is compensated by a corresponding increase of rent.

Thus it appears, that, if tithes were abolished, the rent of such farms as pay tithe would not rise to a level with the rent of those which are tithe-free, but the rents of the latter would fall to the level of the former. As raw produce is uniformly sold at its necessary price, or the price necessary to afford the customary rate of profit to the cultivators of *the worst* land, it would fall the moment they had been relieved from this heavy charge. And the advantage previously enjoyed by the proprietors of tithe-free lands, and which was the only cause of their obtaining a higher rent, being done away, their rents would decline to the level of those around them.

Tithes diminish the Quantity, but increase the Value of Corn Rents.

If rents were uniformly paid *in kind*, the imposition of tithes would undoubtedly diminish the share of the produce paid to the landlord; but as its value would be increased in the precise proportion that its quantity had been diminished, this reduced share would continue to exchange for the same quantity of all other commodities. Thus, if lands of the qualities Nos. 1, 2, 3, &c. respectively produced, in return for the same expenditure, 100, 90, 80, &c. quarters, the rent of No. 1 would be twenty quarters, of No. 2, ten, and so on. But they would no longer preserve that proportion after the imposition of tithes; for, supposing a *tenth* to be deducted from their gross produce, the remaining quantities would be 90, 81, 72, &c.; and, therefore, the corn rent of No. 1 would be reduced to 18, and of No. 2 to nine quarters. It is clear, however, that their money rents, or their rents estimated in any other commodity except corn, would not be at all affected. If corn sold at L. 4 before the imposition of the tithe, it would afterwards sell at L. 4, 8s. 10⅔d.; for, unless ninety quarters now brought as much as one hundred quarters previously brought, the cultivators of those soils, or the employers of those capitals which pay no rent, would not be able to realize the common and average rate of profit. Money rents would, therefore, continue unaltered; on the land No. 1, they would still be L. 80, and on No. 2, L. 40.

It appears, therefore, that in every state of society, whether rents are high or low, and whether they are paid in kind or in money, *the charge of tithes is defrayed entirely by the consumers of raw produce*. They do not consist of a portion of *the rent* of land belonging to the clergy, or the lay-impropriator; but they are a burden which falls equally on every individual in the kingdom—on the poorest beggar as well as the richest lord—in proportion to their respective consumption of the articles from which a tithe is levied.

The Tithe frequently exceeds the Amount of the Rent.

But, independently of these considerations, the fact that tithes and other taxes on raw produce do not form a deduction from rent, but go to increase the price of produce, is obvious from the circumstance that the tithe of expensive crops, and which require a great expenditure in their cultivation, frequently amounts to *four* or *five* times the rent of the land. The Rev. Mr Howlett, by far the ablest advocate of tithes, and whose authority cannot, therefore, be questioned, informs us that the tithe of an acre of hops, raised on land worth 40s. or 50s. an acre, is, after deduction of drying and duty, generally worth from L. 3 to L. 4; and he farther states, that he had known L.7 or L.8 paid for the tithe of an acre of carrot-seed where the land was not worth 20s.! In such cases, it is plainly as great an absurdity to affirm that tithes fall exclusively on the rent of the landlord, as it would be to affirm that a *part* is greater than a *whole*. Tithes cannot justly be objected to on the ground of their being a partial tax. It is a mistake to suppose that they are borne by any particular class. They are not a local but a *general burden;* and fall equally on the consumers of the tithed articles. Had the raiser of carrot-seed been relieved from the burden of tithes, he would have obtained precisely the same rate of profit by selling his produce for L. 7 or L. 8 less; nor, had such been the case, would it have been *optional* with him to have made this reduction; the competition of his neighbours would infallibly have forced him, whether he were so disposed or not, to make a corresponding diminution in his prices. (*Influence on Tithes on Agriculture*, p. 4.)

Effect of Tithes on Prices.

An abolition of tithes is not, therefore, a measure in which landlords and farmers only are interested. It is obviously one of the greatest importance to the public in general. If 80s. be a remunerating price for wheat when tithes are levied, 72s. would be an equally high remunerating price were they remitted. When wheat sells at 80s., tithes, supposing them to be rigorously exacted, are really equivalent to a tax of 1s. a bushel, or 8s. a quarter. And as the average annual consumption of the different kinds of grain by each individual, when reduced to the standard of

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wheat, has been estimated, apparently on good grounds, at a *quarter*, it follows, that when the medium price of wheat is 80s., a tithe on corn is really the same thing as a capitation tax of 8s.; and consequently constitutes an *item* of 40s. in the expenditure of every family of five persons.

Tithes increase according to the increase of *gross* Produce.

But tithes are objectionable on other grounds. They are not a permanent and fixed tax, but they increase according as the difficulty of raising raw produce increases; and are infinitely more burdensome and oppressive in a year of scarcity than in a year of plenty. If the price necessary to afford a sufficient supply of corn were 60s. a quarter, the tithe would be equal to a direct tax of 6s. a quarter; but if, in consequence of being forced to resort to inferior lands, the increased difficulties of production had raised the price to 80s., the tithe would be 8s.; when prices rose to 100s., the tithe would be 10s., and so on. Nor is this all.—The tithe is not only increased in *value*, but it is also increased in *amount*, according as cultivation is extended. When land of the *first* quality, and which we have supposed would yield 100 quarters, was cultivated, the tithe would be 10 quarters: But after land of the *second* quality, and which only yields 90 quarters, had been cultivated, the tithe would be levied on 190 quarters: When land of the *third* quality had been cultivated, it would be levied on 100 + 90 + 80, or 270 quarters, and would go on progressively increasing, both in *value and quantity*, as fresh soils were brought under tillage.

"Not only," says Mr Ricardo, "is the amount of the tax increased from 100,000 quarters to 200,000 quarters, when the produce is increased from one to two millions of quarters, but, owing to the increased labour necessary to produce the second million, the relative value of raw produce is so advanced, that the 200,000 may be, though only twice *in quantity*, yet *in value* three or four times that of the 100,000 quarters which were paid before.

"If an equal value were raised for the Church by any other means, increasing in the same manner as tithes increase, proportionably with the difficulty of cultivation, the effect would be the same. The Church would be constantly obtaining an increased portion of the *net* produce of the land and labour of the country. In an improving state of society, the net produce of the land is always diminishing in proportion to its gross produce; but it is from the net income of a country that all taxes are ultimately paid, either in a progressive or in a stationary country. *A tax increasing with the gross income, and falling on the net income, must necessarily be a very burdensome and a very intolerable tax.* Tithes are a tenth of the gross, and not of the net produce of the land; and, therefore, as society improves in wealth, they must, though the same proportion of the gross produce, become a larger and larger portion of the net produce." *

Difference between Tithe and Rent.

Tithe is certainly in one respect the same as rent; both the one and the other are portions of the produce of the soil converted into a revenue, for the support of those who bear no share of the trouble and expence of its cultivation. But in every other respect they are entirely dissimilar. Rent, when once fixed, must continue the same during the currency of the lease. Though an industrious and enterprising farmer should raise ten or twenty times the quantity of produce raised by a sluggard, his rent would not, therefore, be increased; and he would reap, as he ought, all the advantages of his greater industry and intelligence. Such, however, is not the case with tithes. To the sluggard they are invariable; to the industrious man they become more and more oppressive, and increase with every fresh outlay of capital and labour. It is indisputable, therefore, that in their practical effect, tithes operate as a premium on idleness, and as a heavy and constantly increasing tax on industry! By preventing the cultivator from deriving the full and entire advantage of superior skill and increased exertion, they discourage his efforts, and powerfully contribute to render him indolent, careless, and indifferent. A farmer pays his rent willingly to the landlord; but, he considers the clergyman as an interloper, who, without having contributed in any way to raise the crop, claims a *tenth* part of its *gross* amount. The occupier of a farm, subject to this galling and vexatious charge, can never be brought to consider himself as realizing the same rate of profit from the capital he employs, as his neighbours in tithe-free farms; and so strong is this feeling, that we are told by Mr Stevenson, the well-informed author of the *Agricultural Survey of the County of Surrey*, that it is the common opinion that a farm tithe-free is better worth 20s. an acre, than a tithed farm equally favoured in soil and situation is worth 13s.! In this way, tithes contribute indirectly as well as directly to raise prices—indirectly by generating an indisposition to apply fresh capital to the improvement of the soil, and directly by the positive addition they make to the expence of cultivating bad land.

Tithes a great discouragement to Improvements.

"Of all institutions," says Dr Paley, who cannot surely be reckoned unfriendly to the real interests of the church, "adverse to cultivation and improvement, *none is so noxious as that of tithes.* A claimant here enters into the produce, who contributed no assistance whatever to the production—when years, perhaps, of care and toil have matured an improvement—when the husbandman sees new crops ripening to his skill and industry—the moment he is ready to put his sickle to the grain, he finds himself compelled to divide the harvest with a stranger. Tithes," Dr Paley continues, "are a tax not only upon industry, but upon that industry which feeds mankind—upon that species of exertion which it is the object of all wise laws to cherish and promote." (Paley's *Works*, II. p. 105, ed. 1819.)

"Tithe," says Dr Smith, "is always a great discouragement both to the improvements of the landlord and to the cultivation of the farmer. The one cannot venture to make the most important, which are generally the most expensive, improvements; nor the other to rear the most valuable, which are

* *Principles of Political Economy and Taxation*, 1st edit. p. 228.

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generally, too, the most expensive crops, when the church, which lays out no part of the expence, is to share so largely in the profit. The cultivation of madder was for a long time confined by the tithe to the United Provinces, which, being Presbyterian countries, and, upon that account, exempted from this *destructive tax*, enjoyed a sort of monopoly of that useful dyeing drug against the rest of Europe. The late attempts to introduce the cultivation of this plant into England have been made only in consequence of the statute which enacted that 5s. an acre should be received in lieu of all manner of tithe upon madder." (III. p. 275.) As a farther illustration of the principle here stated, we may mention, that the cultivation of flax and hemp in Ireland never succeeded until a low *modus* had been fixed by law; since then it has made a most rapid progress.

Inquiry into the effect of Taxes on Raw Produce on the Freedom of Intercourse between different Countries.

The effect of tithes and other taxes on the price of raw produce has been urged as a reason why an equal duty should be imposed on all such produce when imported from abroad. But all foreign corn imported must be paid either directly or indirectly by an exportation of some species of manufactured commodities; and it is, therefore, clear, that the home producers of corn can have no claim whatever to a protecting duty on the importation of foreign corn, unless the tithes, and other taxes falling on raw produce, exceed those which fall on manufactured goods. A tax which equally affects every description of products, leaves their relative values exactly where it found them. It does not render any particular class less able to withstand the unrestricted competition of foreigners than the others, and cannot, therefore, entitle them to a protecting duty. But if higher duties be laid on a particular class of commodities, the case is different. If, for example, while the duty on commodities in general is only 10 *per cent.*, a duty of 20 *per cent.* were laid on a particular class, their price must rise 10 *per cent.* higher than the price of the rest, in order to maintain their producers in the same relative situation as before. It is plain, however, that in the event of the ports being opened to the importation of every description of foreign goods free of duty, the producers of the heavily-taxed commodities will be deprived of the means of limiting their supply, and consequently of raising their price, so as to indemnify them for the excess of the tax. The 10 *per cent.* excess of duty would then really operate as a bounty on the importation of the class of commodities on which it is charged; and if it were not defeated by a protecting duty of 10 *per cent.*, the home producers of that class would be placed in a relatively disadvantageous situation, and would abandon their business.

But this principle only holds in the case of duties affecting manufactured products. If a direct tax of 10 *per cent.* were laid exclusively on the hats produced in England, and on no other commodity, the hatters would most likely be ruined were foreigners permitted to import hats duty free. Manufactured goods are produced under the same, or, at all events, under *very similar* circumstances; so much so, that foreign competition must either be injurious to all the manufacturers of a particular description of goods, or to none. But in agriculture the case is otherwise. Corn is produced under *very different* circumstances, or from soils of very different degrees of fertility; and though the cultivators of the worst lands in tillage at any particular period might be injuriously affected by the unrestricted admission of foreign corn, the other cultivators, instead of being injured, would be really benefited by the rise of profit which must always follow every *permanent reduction* in the price of raw produce. Thus, suppose no duties are imposed on manufactured commodities, and that the ports are thrown open to the importation of foreign corn, without any protecting duty to balance the tithe—the whole effect of such a measure would be to cause such a small additional quantity of bad land to be thrown out of tillage as would enable the cultivators to obtain *eleven* quarters for the same outlay that had previously been required to produce *ten* quarters. As soon as this contraction of tillage had been effected, the farmers would have nothing to fear from foreign competition. They would still obtain the same rate of profit that was obtained by the undertakers of other businesses; and the consumers would be able to purchase their corn for *ten per cent.* less than if a protecting duty had been imposed.

Duties on the Importation of Raw Produce into a Country where Tithes and other Taxes are charged on the Raw Produce raised at Home.

But notwithstanding it is thus most certainly true, that the cultivators are always in a condition to relieve themselves of such taxes as affect them to a greater extent than they affect the other classes of society; yet, as they can only do this by contracting tillage and withdrawing capital from the cultivation of inferior soils, the effect of admitting foreign corn without a protecting duty equivalent to the *excess* of taxation affecting the home-growers, would be to cause a diminution of rent. We have already shown that rent consists of the difference between the produce obtained from the best and worst lands under cultivation; and if, by admitting foreign corn duty free, bad land should be thrown out of cultivation, the rent of the landlords would be reduced, and their relative situation lowered. Although, therefore, it is not necessary for the protection of the cultivators that any countervailing duty should be laid on raw produce imported from abroad; still, if it be really true that higher duties are laid on the raw produce raised at home than on manufactured goods, justice to the landlords requires that a duty should be laid on all foreign raw produce equivalent to the *excess of duty affecting home produce*. Such a duty, by fitting all classes equally to withstand foreign competition, will preserve them in the same relative situation after the opening of the ports as previously; and will treat all parties, as they ever ought to be treated, with the same equal and impartial justice.

To whatever extent a countervailing duty might be laid on a foreign commodity, it would be proper to give the home producers of the same commodity an equal, or nearly equal drawback. If the home producers were refused such a drawback, they might say, "Before your duty, and before the price of our produce was raised in consequence of it, we could compete with the foreign grower in foreign markets; by making the remunerating price of our corn higher, you have deprived us of that advantage, therefore give us a drawback equal to the duty, and you, in every respect, restore us to the position, both as it regards our own countrymen, as producers of other

Taxes on Raw Produce.

commodities less heavily taxed, and foreign growers of raw produce, in which we were before placed." On every principle of justice, says Mr Ricardo, and consistently with the best interests of the country, this demand should be acceded to. (*On Protection to Agriculture*, p. 16.)

Mr Ricardo thinks that the tithes and other taxes exclusively affecting raw produce, over those affecting manufactured goods, may be taken at about 10s. a quarter; and he therefore proposes that foreign corn should be freely admitted on paying this duty, and that a drawback of 7s. should be allowed on exportation. "The duty of 10s. a quarter is, I am sure, rather too high as a countervailing duty for the peculiar taxes which are imposed on the corn-grower, over and above those which are imposed on the other classes of producers in the country; but I would rather err on the side of a liberal allowance than of a scanty one; and it is for this reason that I do not propose to allow a drawback quite equal to the duty." (*Ibid*. p. 80.)

The necessity of imposing this countervailing duty, originating, as it almost entirely does, in the imposition of tithes, affords another and a very powerful argument in favour of their abolition or commutation. Were tithes abolished, the protecting duty proposed by Mr Ricardo might be reduced to 3s. or 4s. a quarter, and the drawback to 2s. or 2s. 6d.

Taxes on Raw Produce raise Wages and lower Profits.

Taxes on raw produce, by raising the price of the articles required for the food of the labourer, necessarily raise wages and lower profits. Such taxes, therefore, fall with double weight on the capitalists; affecting them both as employers of labour, and as consumers. Indeed, the principal disadvantage of taxes on raw produce consists in their tendency to lower profits. "With a permanently high price of corn," says Mr Ricardo, "proportional wages would be high; and, as commodities would not rise on account of the rise of wages, profits would necessarily fall. If goods, worth L.1000, require, at one time, labour which cost L.800, and, at another time, the price of the same quantity of labour is raised to L.900, profits will fall from L.200 to L.100. They will fall not in one trade only, but in all. High wages equally affect the profits of the farmer, the manufacturer, and the merchant; nor is there any other way of keeping profits up than by keeping wages down. In this view of the law of profits, it is at once seen how important it is that so essential a necessary as corn, which so powerfully affects wages, should be sold at a low price; and how injurious it must be to the community generally, that, by prohibitions against importation, we should be driven to the cultivation of our poorer lands to feed our increasing population."

Customs.

4. *Custom Duties, or Duties on the Importation and Exportation of Commodities.*—These, like all other duties, are paid by the consumers of the commodities on which they are laid. When a government lays a duty on the foreign commodities which enter its ports, the duty falls entirely on its own subjects who purchase such commodities; for the foreigners would cease supplying their markets with them, if they did not get the full price of the commodities exclusive of the tax; and, for the same reason, when a government lays a duty on the commodities which its subjects are about to *export*, the duty does not fall on them, but on the *foreigners by whom they are bought*. If, therefore, it were possible for a country to raise a sufficient revenue by laying duties on exported commodities, such revenue would be wholly derived from others, and it would itself be entirely relieved from the burden of taxation; except in so far as duties might have been imposed by foreigners on the commodities it imports from them! Care, however, must be taken in imposing duties on exportation, not to lay them on such commodities as can be produced at nearly the same cost by foreigners, for the effect of the duty would then be to put an entire stop to their exportation, by causing the market to be supplied by others. But when a country possesses any exclusive, natural, or acquired advantage, in the production of commodities, a duty on their exportation is really the most unexceptionable of all taxes. Such a duty would not fall upon itself, but upon its foreign customers; and if it were not carried so high as to balance the superior facilities of production, it would have only a very slight tendency to diminish the demand for the taxed articles. If the Chinese chose to act on this principle, they might derive a very considerable revenue from a duty on exported teas, which would have to be entirely paid by the English and other foreigners who buy them. And there is perhaps no country which does not possess some commodity demanded by foreigners that might not be advantageously charged with a moderate duty on exportation. The coal and tin, and probably also some species of the manufactured goods of Great Britain, seem to be in this predicament.

Custom Duties.

It was the great object of the professors of the *mercantile* system of political economy to facilitate the exportation of commodities of domestic growth, and to fetter and restrict the importation of those produced abroad; and it is to the prevalence of this system in modern Europe, and its influence on financial legislation, that we are to ascribe the almost total exemption of exported commodities from duties, and the ruinous extent to which they have been heaped on those that are imported.

Duties on imports and exports have been levied in almost every country which had any foreign commerce. The Athenians laid a tax of a *fifth* on the corn and other merchandise imported from foreign countries, and also on several of the commodities exported from Attica.* The *portoria*,† or customs payable on the commodities imported into, and exported

* Anacharsis's *Travels*, IV. p. 375, Eng. Trans. The quantity of corn usually imported from the countries on the Euxine into Athens amounted to about 400,000 medimni. See Clarke *On the Connection between the Roman and English Coins*, p. 58.

† Huic vero proprie *vectigalis* denominatio convenit quippe pro vehendis mercibus (unde *vectigal*), soluto. Burman, *De Vectigalibus Pop. Rom.* cap 5.

Custom Duties.

from, the different ports in the Roman empire, formed a very ancient and important part of the public revenue. They were imposed, as Tacitus has observed, when the spirit of liberty ran highest among the people. *A consulibus et tribunis plebis institutæ, acri etiam populi Romani tum libertate.* (*Annal.* lib. 13, cap. 50.) The rates at which they were charged were fluctuating and various, and little is now known respecting them. Cicero informs us (Cic. in II. Ver. cap. 75), that the duties on corn exported from the ports of Sicily were, in his time, 5 *per cent.* Under the Imperial Government the amount of the *portoria* depended as much on the caprice of the Prince as on the real exigencies of the state. Though sometimes diminished, they were never entirely remitted, and were much more frequently enlarged. Under the Byzantine Emperors they were as high as 12½ *per cent.* (Burman, *De Vectigalibus Pop. Rom.* cap. 5, *passim.*)

Customs seem to have existed in England before the Conquest. But the King's first claim to them was established by statute of the 3d Edward I. The inconveniences arising from the multiplicity of the various separate acts relative to the customs, caused Mr Pitt to introduce a bill, in 1787, for their consolidation. This bill was passed into a law, and several similar consolidations have since been effected. The last was by a statute passed in 1819. To this statute are subjoined tables, containing lists, ranged in alphabetical order, of the various articles of import and export, with the duties payable on each, and the drawbacks and bounties allowed on the exportation of particular sorts of British goods.

Seignorage.

5. *Duties on the Coinage of Gold and Silver.*—For an account of the incidence and effect of these duties, the reader is referred to the article MONEY in this *Supplement*, cap. *Seignorage.*

Stamp Duties.

6. *Stamp and Legacy Duties.*—Stamp duties are duties laid on the paper or parchment, on which certain deeds, contracts, legal proceedings, receipts, acquittances, &c. are written. They are called stamp duties, from the paper being impressed with a public stamp, stating the amount of the duty. The ultimate incidence of these duties varies according to the nature of the deed or writing, for which it is necessary to use stamped paper.

Duties on the Sale of Land generally fall on the Sellers.

The duties payable on the sale of land, or on the paper used in its conveyance from one party to another, commonly fall on the seller. This arises, as Dr Smith has observed, from the circumstance of "the seller being almost always under the necessity of selling, which forces him to take such a price as he can get. The buyer is scarce ever under the necessity of buying; he will, therefore, only give such a price as he likes. He considers what the land will cost him in tax and price together. The more he is obliged to pay in the way of tax, the less he will be disposed to give in the way of price. Such taxes, therefore, fall almost always upon a necessitous person, and must, therefore, be frequently very cruel and oppressive." (III. p. 318.) It is obvious that the same reasoning must hold in the case of the duties chargeable on the granting of mortgages; and that they will commonly fall on the borrower or poorer party.

Stamp and Legacy Duties.

Disadvantage of Stamp Duties when they affect the transfer of Property.

This, however, is not the only objection to the imposition of duties on the transference of property. Both M. Say and Mr Ricardo have observed, that the tendency of such duties is to prevent property from coming into the hands of those who would use it most advantageously; and consequently to prevent the national capital from being distributed in the best way for the community. For the general prosperity, there cannot be too much facility given to the conveyance and exchange of all kinds of property, as it is by such means that capital of every species is likely to find its way into the hands of those who will best employ it in increasing the productions of the country. "Why," asks M. Say, "does an individual wish to sell his land? it is because he has another employment in view in which his funds will be more productive. Why does another wish to purchase this same land? it is to employ a capital which brings him too little, which was unemployed, or the use of which he thinks susceptible of improvement. This exchange will increase the general income, since it increases the income of these parties. But if the charges are so exorbitant as to prevent the exchange, they are an obstacle to this increase of the general income." *

Taxes on Law Proceedings.

Taxes on law proceedings fall upon the suitors; and consequently operate as a check to prevent an injured party from seeking redress in a court of justice. The impolicy, hardship, and injustice of such taxes, have been admirably exposed by Mr Bentham, in his *Protest against Law Taxes.*

Stamp duties, on the voluntary sale of all those articles which are the produce of human industry, fall, like all other taxes on such articles, wholly on the consumer; for, unless such were the case, the articles would not be offered for sale, subsequently to the imposition of the duties. Thus, the duties on cards and dice, on advertisements, newspapers, &c. are all paid by those who use them. Such, too, is the case with the stamp duties, payable on licences to retail any species of goods, or to exercise any profession. The taxed party invariably adds as much to the price of the articles in which he deals, or of the services which he performs, as is sufficient to indemnify him for the tax.

Stamp Duties first levied in Holland.

Stamp duties were first levied in Holland. Most of the accustomed methods of taxation having been resorted to, the Republic, in order to provide additional funds for carrying on her contest with the Spanish monarchy, offered a considerable reward to any one who should devise the best new tax! Among many other taxes, that of the *vectigal chartæ*, or stamp duty, was suggested; and having been approved of, it was introduced by an Ordinance issued in 1624, setting forth its necessity, and the benefits which it was supposed would result from its imposition. † Since that period, stamp duties have

* Ricardo, *Principles,* &c. p. 167. 3d Ed. and Say, *Traité d'Economie Politique,* Tome II. p. 351.

† Beckman's *History of Inventions,* Vol. I. p. 379. Eng. Trans. 10

Stamp and Legacy Duties.

become almost universal, and now form a very prominent branch of the revenue of almost every country; affording a striking example of the justice of Dr Smith's remark, that "There is no art which one government sooner learns of another, than that of draining money from the pockets of the people." (III. p. 317.)

Stamp duties were introduced into England in 1671, by a statute entitled, "An act for laying impositions on proceedings at law." The duties were at first granted for only nine years, and were afterwards continued for three years more, when they were allowed to expire. They were again revived in 1693, and have since been gradually and greatly increased.

Legacy Duties in Rome.

Legacy Duties, or duties on the transference of property from the dead to the living, are now a very common species of tax. The *vicesima hereditatum*, or the twentieth penny of inheritances, imposed by Augustus on the Romans, is the earliest example of a tax on successions. Dion Cassius (lib. 55) informs us, that this duty was laid on all successions, legacies, and donations in case of death, except upon those to the nearest relations and to the poor. Pliny has given some of the reasons for this exception; in speaking of the *Vicesima*, he calls it *tributum tolerabile et facile hæredibus duntaxat extraneis, domesticis grave*. And a little after he adds, *Itaque illis* (that is strangers) *irrogatum, his* (that is near relations) *remissum, videlicet, quod manifestum erat, quanto cum dolore laturi, seu potius non laturi homines essent, distringi aliquid et abradi bonis, quæ sanguine, gentilitate, sacrorum denique societate meruissent, quæque nunquam ut aliena et speranda, sed ut sua semperque possessa, ac deinceps proximo cuique transmittenda, cepissent. (Panegyricus*, cap. 37.) In addition to these very cogent reasons for exempting the successions of near relations from the *vicesima*, it may be observed, that the death of a father is seldom attended with any increase, and frequently with a considerable diminution, of revenue to such of his children as live in the same house with him; and when this is the case, the burdening of his inheritance with a tax must plainly be a very galling and cruel aggravation of their loss. But, if taxes on successions are always paid with very great reluctance by the children and immediate relations of the deceased, it is quite otherwise when they fall to distant relations or strangers. Those on whom an unexpected or remote inheritance devolves, are glad to accept it on any condition; and uniformly pay such moderate duties as may be laid on it with greater good will than any other impost whatever!

In England.

In Great Britain, a duty of *one per cent.* is laid on all successions devolving either to the children, or to any lineal descendant of the children of the deceased, or to his father or mother, or to any of his lineal ancestors; a duty of *three per cent.* is charged on successions devolving to brothers and sisters; of *four per cent.* on those devolving to cousins; and of *ten per cent.* on those devolving to strangers. Exclusive of this, a farther duty, varying according to the amount of the property left by the deceased, is also charged on the probates of all wills, without regard to the propinquity of the successors. This duty amounts, at present, to L. 11 on a property worth from L. 450 to L. 600; to L. 22 on a property worth from L. 800 to L. 1000; and to L. 180 on a property worth from L. 8000 to L. 10,000, increasing according to the farther increase of the property. This tax presses more severely on lineal successors, and is more objected to by them than the legacy duty.

Objection to Legacy Duties.

The great objection to taxes on successions, or on transference of property from the dead to the living, consists in the circumstance of their falling wholly on capital, without occasioning any effort to replace it, either by increased exertion or economy. If a legacy of L. 1000 be subject to a tax of L. 100, the legatee considers his legacy as only L. 900, and feels no particular inclination to save the L. 100 from his expenditure; whereas, had he received the whole L. 1000, and been required to pay L. 100 in taxes on income or commodities, the desire to preserve his capital unimpaired would have prompted him to endeavour to defray the tax by increased industry and economy. The real advantage of the legacy duties consists in the facility with which they are collected; for by tending directly and necessarily to diminish capital, they are, in most other respects, extremely injurious.

Postage of Letters.

7. *Postage of Letters.*—The conveyance of letters by post has, in almost all countries, been conducted by the agents of government; and it is one of the few industrious undertakings which appear to be better managed by them, than they could be by private individuals. This species of conveyance was originally established, and kept up by the Roman Emperors, for the safe, regular, and speedy transmission of the public dispatches to the most remote parts of their dominions; and such was also the purpose for which posts were first established in modern Europe, by Louis XI. Subsequently, however, private individuals were allowed to avail themselves of this institution, for the conveyance of their letters; and governments, by imposing higher duties, or rates of postage, on the letters and packages sent through the post-office than are sufficient to defray the expence of the establishment, have rendered it productive of a considerable revenue.* Nor, while the rates of postage are confined within reasonable limits, is there perhaps a more eligible species of tax. The English post-office was placed on nearly its present footing in 1649, by the exertions of Mr Edmund Prideaux, Attorney-General to the Commonwealth.—(See Blackstone's *Commentaries*, I. p. 321.)

The limits within which this article must be confined will not allow us to enter at greater length into the inquiry concerning the incidence of taxes on commodities. We shall, therefore, proceed briefly to investigate their capacity to produce a revenue.

* Bergier, *Histoire des Grands Chemins de l'Empire Romain*, I. p. 199.

High and Low Duties.

SECT. III.—*Circumstances which determine the extent to which Taxes ought to be laid on Commodities—Causes of Smuggling—Means by which it may be prevented.*

Low Duties most Productive.

With regard to the capacity of a tax on a commodity to raise a revenue, it depends, *first*, on the nature and extent of the demand for the commodity; and, *second*, on the means of preventing its being smuggled. Every tax, by raising the price of the commodity on which it is laid, has a tendency to bring it within the command of a smaller number of purchasers, and to lessen its consumption. An individual who might be able and disposed to pay 1s. a bottle of duty on wine, might neither have the means nor the inclination to pay 2s. or 3s.; and instead of being augmented, the revenue might be diminished by such an increase of duty. And hence, whenever the duties on commodities are raised beyond a certain limit—a limit, however, which it is impossible to define, and which must necessarily vary according to the nature of the commodity on which the duties are laid, and the varying tastes and circumstances of society—their effect is to depress consumption to such an extent, as to render them less productive than if they had been lower.

Variations in the amount of the duties affecting commodities have exactly the same effect on their price, and consequently on their consumption, as corresponding variations in the cost of their production. But it is clear that any reduction in the price of commodities, whose natural cost is very considerable, and which can, therefore, be used only by the rich, could not have so powerful an effect, in increasing consumption, as would follow the same proportional reduction in the price of easily produced commodities in general demand. A reduction of 50 *per cent.* from the price of coaches would not add greatly to the demand for them; for, notwithstanding this reduction, they would still be luxuries, for which none but the rich could afford to pay; whereas, a reduction of 50 *per cent.* from the price of whisky, gin, beer, tea, sugar, or any article in general request, would extend the demand for it in a much greater ratio. The reason is plain:—The poorer classes form by far the most numerous portion of society; and as such commodities are even now partially used by them, a fall of 50 *per cent.* in their price would bring them fully within their command, and would thereby add prodigiously to their consumption. The truth of this observation may be strikingly exemplified by a reference to the case of cotton goods. At the Accession of his late Majesty, in 1760, the price of cottons, owing to the difficulty of producing them, was extremely high; and the value of the manufactured cottons annually brought to market did not exceed L. 200,000. But thanks to the genius and inventions of Hargreaves, Watt, Arkwright, Crompton, and others, the price of cottons has been so far sunk, as to bring them within reach of the poorest individual; and yet, such has been the vast increase of demand, that, notwithstanding this reduction of price, the value of the cottons annually manufactured in Great Britain, and either disposed of at home, or sent abroad, amounts, according to the very lowest estimate, to the amazing sum of FORTY MILLIONS! It is obvious, however, that if cottons had been loaded with high duties; and if the same reduction in them, which has been brought about by the improvement in machinery, had been brought about by a reduction of the duties affecting them, precisely the same effects would have followed. The demand would have equally increased; and the greater consumption of the low taxed articles would have rendered the reduced duties more productive than the higher. Similar effects have uniformly followed from similar causes: low duties on commodities in general demand being invariably found to be more productive than when they are carried to a greater height—and more productive than high duties on commodities used only by the rich.

Causes and Prevention of Smuggling.

High Duties encourage Smuggling.

Besides diminishing the revenue by diminishing consumption, oppressively high duties tend to diminish it by encouraging and promoting the ruinously destructive trade of smuggling. The risk of being detected in the smuggling of commodities, under any system of fiscal regulations, may always be valued at a certain average rate; and whenever the duties exceed this rate, smuggling will be immediately practised. Now, there are plainly but two ways of checking this nefarious practice—either the temptation to smuggle must be diminished by lowering the duties, or the difficulties in the way of smuggling must be increased. The first is obviously the most natural and efficient method of effecting the object in view; but the second has been most generally resorted to. In the great majority of cases, governments have attempted to put down smuggling, without reducing the duties, by establishing a more vigilant system of collection, and by increasing the number and severity of the penalties affecting the smuggler. As might have been expected, these attempts have, in the great majority of cases, proved signally unsuccessful. And it has been, almost invariably, found that no vigilance on the part of the revenue officers, and no severity of punishment, can prevent the smuggling of those commodities which are loaded with oppressive duties. The smuggler is generally a popular character; and though we have no desire to become the apologists of those who endeavour to defraud the revenue, and to injure the fair trader, it is idle to expect that the bulk of society will ever be brought to consider that those who furnish them with cheap tea, gin, whisky, brandy, &c. are guilty of any very heinous offence.

"To pretend," says Dr Smith, "to have any scruple about buying smuggled goods, though a manifest encouragement to the violation of the revenue laws, and to the perjury which almost always attends it, would, in most countries, be regarded as one of those pedantic pieces of hypocrisy, which, instead of gaining credit with any body, seems only to expose the person who affects to practise them, to the suspicion of being a greater knave than most of his neighbours. By this indulgence of the public, the smuggler is often encouraged to continue a trade, which he is thus taught to consider as in some measure innocent; and when the severity of the revenue laws is ready

Causes and Prevention of Smuggling.

to fall upon him, he is frequently disposed to defend with violence what he has been accustomed to regard as his just property: and from being at first, perhaps, rather imprudent than criminal, he at last too often becomes one of the hardiest and most determined violators of the laws of society."—(III. p. 378. See also Montesquieu, *Esprit des Loix*, liv. 13, cap. 8.)

A Reduction of Duties the only effectual means of preventing Smuggling.

To create, by means of high duties, an overwhelming temptation to indulge in crime, and then to punish men for indulging in it, is a proceeding completely subversive of every principle of justice. It revolts the natural feelings of the people, and teaches them to feel an interest in the worst characters—for such smugglers generally are—to espouse their cause, and to avenge their wrongs. A punishment which is not proportioned to the offence, and which does not carry the sanction of opinion along with it, can never be productive of any good effect. The true way to put down smuggling is to render it unprofitable—to diminish the temptation to engage in it; and this is to be done, not by surrounding the coasts with cordons of troops, by the multiplication of oaths and penalties, and making the country the theatre of ferocious and bloody contests in the field, and of perjury and chicanery in the courts of law, but simply and exclusively by *reducing the duties on the smuggled commodities.* It is in this, and in this only, that we must seek for an effectual check to smuggling. Whenever the profits of the fair trader become nearly equal to those of the smuggler, the latter is forced to abandon his hazardous profession. But so long as oppressively high duties are kept up, or, which is really the same thing, so long as a *high bounty* is held out to encourage the adventurous, the needy, and the profligate, to enter on this career, we may be assured, that an army of excise officers, backed by the utmost severity of the revenue laws, will be insufficient to hinder them. The truth is, that the too great severity of these laws prevents their execution. "It stimulates the trader to corrupt the officer to conceal a fraud; and it influences the officer to overlook what he would otherwise discover." (Hamilton *On the Principles of Taxation*, p. 244.)

Duties should vary directly as the Price of the Commodity.

Heavy duties on any description of commodities will occasion smuggling; but, it is chiefly caused by their being laid on commodities in general demand, whose natural or necessary price is not very considerable. It is commonly said, when a proposal is made for laying a heavy duty on a low priced article, that its lowness of price fits it to bear such a duty, and that, notwithstanding its imposition, it may still be brought to market at a sufficiently moderate rate. But the encouragement to smuggling depends more on the *proportion* which the duty bears to the price of the commodity, than on the circumstance of the duty being absolutely high or low. To illustrate this principle, let us suppose, that a taxed commodity, as soap, costs, exclusive of duty, 10d. a pound. If a duty of 1d. *per* lib. were laid on it, the inducement to smuggle would be equal to 10 *per cent.* of the value of the article, and if the duty were 2d. the inducement would be 20 *per cent.*, and so on. Now, let us suppose, that the cost of producing the soap, or its natural price, falls to 5d.: a duty of 1d. *per* lib. would then make an inducement to smuggle of 20 *per cent.* of its value, and a duty of 2d. would make an inducement of no less than 40 *per cent.*! And hence, it is obvious, that, in order to prevent smuggling, a system should be adopted, precisely the reverse of that which is generally followed in the imposition of taxes. Instead of making duties to vary *inversely* as the price of commodities, or of raising them when the natural prices of the taxed articles fall, and reducing them when they rise, they ought to be made to vary *directly* as these prices—to rise when they rise, and to fall when they fall. *Disproportionally* heavy taxes are the great cause of smuggling; and they have the farther and most injurious effect of preventing its being corrected by its natural and proper punishment, the *confiscation* of the commodities. Recourse is, in consequence, had to extraordinary pains and penalties, and all proportion of punishment being done away, "men who," as Montesquieu observes, "can hardly be considered as culpable, must be punished as atrocious criminals." (*Esprit des Loix*, liv. 13, cap. 8.)

Comparative Productiveness of High and Low Taxes.

Certain commodities, from their greater bulk, from their susceptibility of being impressed with a permanent stamp, or from any other cause, are less liable to be smuggled than others, and may, therefore, be loaded with comparatively higher duties. But as a general rule, it cannot be doubted, that, in order to prevent fraud, the duties should always be proportioned to the cost of the articles on which they are laid.

Sect. IV.—*Comparative Productiveness of High and Low Taxes.*

The arguments adduced in the foregoing *section* are sufficient to establish the superior productiveness of moderate taxes. But the subject deserves to be treated at greater length: and as the history of taxation, both in this and other countries, furnishes numerous direct, conclusive, and well established proofs of the same principle, we shall take this opportunity to bring a few of them under the notice of our readers. We shall class them under two different heads: the *first*, consisting of instances wherein a reduction of duty has been followed by an increase of revenue; and the *second*, of instances wherein an increase of duties has been followed by a diminution of revenue.

History of the Tea Duties.

1. The effects produced by the reduction of the tea duties, in 1745 and 1784, are among the most striking examples of the superior productiveness of low duties on articles in general demand. Previously to 1745, the excise duty of 4s. a pound on tea yielded, at an average, about L.150,000 a year; which, had there been no smuggling or adulteration, would have shown that the consumption was equal to about 750,000 lbs. But it was well known that smuggling was then carried to a very great height, and that the real consumption of tea was much greater than the apparent consumption. To put a stop to this clandestine importation, a bill was introduced into Parliament in 1745, in pursuance of the recommendation of a Committee of the House of Commons, and passed into a law, by which the excise duty of 4s. was reduced to 1s., and 25 *per cent. ad valorem.* This measure was signally successful.

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In 1746, the year immediately subsequent to the reduction, the sales of tea for home consumption amounted to above TWO MILLIONS of pounds weight, and the revenue was increased to L. 243,309! But to set the effects of this wise and salutary measure in a still clearer point of view, we shall subjoin an account of the net produce of the tea duties from 1743 to 1748, both inclusive.

In 1743	it amounted	to	L. 151,959
1744	—	—	147,065
1745	—	—	145,630
1746	(Duties reduced)		243,309
1747	—	—	257,937
1748	—	—	303,545. *

But notwithstanding this unanswerable demonstration of the superior productiveness of low duties, they were again increased in 1748; and fluctuated, between that epoch and 1784, from 64 to 119 *per cent. ad valorem*. The effects which followed this inordinate extension of the duties are equally instructive with those which followed their reduction. The revenue was not increased in any thing like a corresponding proportion; and as the use of tea had become general, smuggling was carried to an infinitely greater extent than at any former period. In the *nine* years preceding 1780, above 118 millions of pounds weight of tea were exported from China to Europe, in ships belonging to the Continent, and about 50 millions of pounds in ships belonging to England. But from the best information attainable, it appears that the real consumption was almost exactly the reverse of the quantities imported; and that, while the consumption of the British dominions amounted to above 13 millions of pounds, the consumption of the Continent did not exceed 5½ millions! If this statement be nearly correct, it follows that an annual supply of about *eight* millions of pounds must have been clandestinely imported into this country, in defiance of the utmost vigilance on the part of the revenue officers. But this was not the worst effect of the high duties; for many of the retail merchants, who purchased tea at the East India Company's sales, being in a great measure beat out of the market, were, in order to put themselves in a condition to stand the competition of the smugglers, tempted to adulterate their teas, by mixing them with sloe and ash leaves.† At length, in 1784, ministers, after having in vain tried every other resource for the suppression of smuggling, resolved to follow the precedent of 1745, and reduced the duty on tea from 119 to 12½ *per cent.* This measure was as successful as the former. Smuggling and the practice of adulteration were immediately put an end to. The following official statement shows, that the *quantity* of tea sold by the East India Company was about *tripled* in the course of the *two* years immediately following the reduction!

In 1781, the quantity of tea sold at the East India Company's sales amounted to 5,023,419 lbs.

1782	—	—	6,283,664
1783	—	—	5,857,883
1784	(Duties reduced)		10,148,257
1785	—	—	16,307,433
1786	—	—	15,093,952
1787	—	—	16,692,426 ‡

While the quantity of tea sold at the Company's sales was thus rapidly augmenting in consequence of the reduction of the duty, the quantity of tea imported into the Continent from China, which had, in the year 1784, amounted to 19,027,300 lbs., declined with still greater rapidity, and, in 1791, was reduced to only 2,291,500 lbs.! §

The duties on tea, on an average of the five or six years preceding 1784, produced about L. 700,000 a year. And, at the same time that Parliament reduced them to 12½ *per cent.*, they laid an additional duty on windows, estimated to produce L. 600,000, as a *commutation* tax, to compensate the deficiency which it was supposed would take place to that extent in the revenue formerly derived from tea. But instead of the duties falling off in the proportion of 119 to 12½, or from L. 700,000 to L. 73,000, owing to the increased consumption, they only fell off in the proportion of about *two* to *one*, or from L. 700,000 to L. 340,000! The commutation act has been always regarded, and with justice, as one of the most successful financial measures adopted in the course of Mr Pitt's administration. The plan was generally understood, at the time, to have been suggested by Mr Richardson, Accountant-General of the East India Company. But the popularity of the measure was so great as to induce several other individuals to claim this honour, and even to occasion some hot disputes on the subject in the House of Commons. In point of fact, however, the merit of having first suggested the plan did not really belong either to Mr Richardson, or to any of those who then claimed it; and such of our readers as will take the trouble to look into a pamphlet of Sir Matthew Decker's (*Serious Considerations on the Present High Duties*), published in 1743, will find that the measure adopted in 1784 had been strenuously recommended forty years before.

But the principle of the commutation act, and the striking advantage that had resulted from the reduction of the duty, were soon lost sight of. In 1795, the duty was increased to 25 *per cent.*; and after successive augmentations in 1797, 1798, 1800, and 1803, it was raised, in 1806, to 96 *per cent. ad valorem*, at which it continued till 1819, when it was raised to 100 *per cent.* Now, although it cannot be disputed that the duty on tea yields, at present, a vastly greater revenue than was derived from it in 1795, there are the strongest possible reasons for believing that the revenue would have been considerably greater,

* Hamilton's *Principles of Taxation*, Appendix, No. 19; and Postlethwaite's *History of the Revenue*, p. 293.

† Macpherson's *Commerce with India*, p. 208. Milburn's *Oriental Commerce*, Vol. II. p. 540.

‡ Macpherson's *Commerce with India*, p. 416.

§ Ibid. p. 210.

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had the duty not been carried so high. The quantity of tea sold by the East India Company in 1795 and 1796 amounted to very nearly 20 millions of pounds a year, and in 1799, to very nearly 25 millions of pounds (24,853,508). Since then, there has been *no increase*. For, according to the account given in the *Lords' Report on the East India Trade* (p. 334), the average quantity of tea sold at the Company's sales in 1818, 1819, and 1820, is rather under 25 millions of pounds a year. But the population of Great Britain, which is ascertained by the late census to amount to 14,379,000, amounted to only 10,817,000 in 1800; and had there been no diminution of the individual consumption of the Company's tea in the interval between these enumerations, their sales ought plainly to have been increased in the proportion of 10,817 to 14,379, or from 25 to 33 millions of pounds. Nor is this all. The sales made by the East India Company supply the markets of Ireland as well as Britain; and, if we take into account the extraordinary increase of population in that part of the empire, the diminution of consumption will appear still more striking. But, notwithstanding the Company's sales have thus continued stationary since 1795, it is, we believe, pretty generally admitted, that the individual consumption of tea, or rather of the compound sold under its name, has not been considerably diminished in the towns, while it has increased greatly in the country since that epoch. It is plain, however, that this increased supply can have been obtained only by clandestine importation, or adulteration; and, as there was no opportunity of smuggling during the latter part of the war, and as the powerful force that has been employed in the preventive service since the return of peace, must have rendered it extremely difficult to import any considerable quantity of foreign tea, we should be disposed to conclude, that the vacuum, caused by the high duties, has been chiefly supplied by adulteration,—and such, we find, is really the case. There is, indeed, every reason to think that the practice of adulterating by the intermixture of ash and sloe leaves, and by drying tea that has been already infused, and mixing it with fresh tea, is carried to a greater extent at this moment than in 1784. In proof of this, we may mention, that, in London, in 1818, upwards of twenty grocers were convicted of having spurious tea in their possession. And it is worthy of remark, that in the case of the King *v.* Owen, the counsel for the defendant declared, that *the practice was so general, that his client was not aware of the existence of any law by which it was forbidden!* Since then, several additional convictions have taken place; but it is not in the nature of things that the evil can be materially diminished by such means. If we are really desirous of putting a stop to the practice of adulteration, we must follow Mr Pitt's example, and take 50 or 60 *per cent.* from the present duties. The experience of the effects of the reductions in 1745 and 1784, enable us confidently to predict, that such a reduction would not be followed by any corresponding diminution of revenue; while, besides putting an instant stop to smuggling and adulteration, it would be a considerable boon to the lower classes, to whom tea is now become an article of prime necessity, and would powerfully contribute to extend our commerce with China.

We have been thus particular in noticing the variations in the tea duties, because the Company's sales afford the means of ascertaining the precise effect of their increase and diminution on consumption. The results are both curious and instructive; and would of themselves be sufficient to establish the truth of Dr Swift's observation, that, in the arithmetic of the Customs, two and two do not always make *four*, but sometimes only *one!*

Effects of the Reduction of the Spirit Duties.

The narrow and contracted policy on which most ministers have generally acted, puts it out of our power to refer to many such conclusive instances as the reduction of the tea duties in 1745 and 1784, to prove the superior productiveness of diminished taxation; there are, however, one or two others which deserve to be pointed out. In 1742, the high prohibitory duties upon spirituous liquors, and upon licences for retailing the same, were abolished, and such moderate duties imposed, to commence after Lady Day 1743, as were expected to increase the revenue by increasing the legal consumption of spirits. This measure was vehemently opposed by the Bishops; but their opposition was ineffectual; and the increase of the duties, and diminution of smuggling which followed, proved that the measure was alike advantageous to the revenue and to the morals of the people. (*History of our Debts and Taxes*, Part IV. p. 110.) In 1787, Mr Pitt reduced the duty on wine and spirits 50 *per cent.* and the revenue was, notwithstanding, considerably *augmented*. Perhaps, however, the progress of the duties on coffee illustrates this principle in a still more striking manner.

Reduction of the Coffee Duties.

In 1805, they were raised a *third*, and that year their produce *fell off* an eighth instead of increasing a third; in 1806, they had increased only a *sixteenth*, so that the consumption had diminished above a fourth. But it was at length found that the tax had been overdone, and it was lowered from 2s. to 7d. the cwt. Mark the immediate effects of this step. The average annual produce of the high duty for the three years, previous to 1808, when it was lowered, was L.166,000; and the average annual produce of the reduced duty for the next three years was L.195,000—a proof that the consumption had been increased in a *quadruple* proportion. *

Reduction of the Duties on Fish sold in Paris.

The history of other countries abounds with equally conclusive examples of the superior productiveness of moderate duties. In 1775, M. Turgot deducted a *half* from the customs and other duties chargeable on the fish sold in the Paris market; but, notwithstanding this reduction, the amount of the duties collected was not diminished. The demand for fish must, therefore, have been doubled, in con-

* Mr Brougham's *Speech on the State of the Nation in* 1817, p. 57.

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sequence of the inhabitants being enabled to supply themselves, at a comparatively cheap rate, with a nutritious and agreeable food.*

Reduction of the Duties on Sugar imported into France.

In 1813, all sugar imported into the French empire paid a duty of one franc sixty cent. the *livre* or pound. The quantity imported that year amounted to about fourteen millions of pounds, which, as France, and the countries then incorporated with her, contained about forty-two millions of inhabitants, gives the *third* part of a pound weight to each. In 1814, this exorbitant duty was reduced to about a *fifth* part, or to thirty cent. the pound; and, though the population of France had now been reduced from forty-two to about twenty-eight millions, the average annual importations of 1814 and 1815 amounted to forty-four millions of pounds, being upwards of a *pound and a half* to each individual; or about FIVE *times as much as the consumption had amounted to under the high duty.* In consequence of this increase of consumption, the low duty yielded very near as large a revenue as the high duties; and, since 1815, both consumption and revenue have continued to increase. (*Richesse des Nations*, par Garnier, V. p. 304, 2de Ed.)

Reduction of the Duties on Provisions in Spain.

Ustariz gives a variety of instructive details respecting the disastrous effects which the levying of certain taxes have had on the industry of the Spaniards, and of the advantage which has resulted from the repeal and modification of others. We shall give a single example. Valencia, he tells us, though very barren of grain and flocks, and not equal in extent to two-thirds of Arragon, paid *a much larger revenue to the Royal Treasury.* He says, that this was owing to the comparatively flourishing state of commerce and manufactures in Valencia; and he then adds—"This increase and improvement in manufactures and commerce is ascribed to the equitable and kind treatment the weavers receive in that province, and to his Majesty's goodness in *reducing the excessive taxes* which were charged upon *flesh meat and other provisions;* and his taking off wholly that which was laid on *bread* in ancient times; as also, the imposts known by the name of *ancient duties and generalities.* These duties were partly replaced by others, but in such a manner that they were rendered much lighter, the people in general eased, and the royal revenue improved."†

Effects of the Increase of the Sugar Duties.

2. But the superior productiveness of low duties on articles in general request may be equally shown from the consequences of the attempts to increase them beyond their proper limits. The history of the sugar duties is, in this respect, extremely important. In the three years from 1803 to 1806, the former duties were increased about 50 *per cent.* Now, the average produce of the old duties, for the three years before that rise, was L. 2,778,000. The produce of 1804, after they had been raised 20 *per cent.*, was not L. 3,333,000, as it ought to have been, had the consumption remained the same, but only L. 2,537,000, being L. 241,000 *less* than the produce of the low duty; and the average produce of 1806 and 1807, after the whole 50 *per cent.* was added, was only L. 3,133,000, instead of L. 4,167,000; which it should have been had there been no falling off since 1804. Thus, both consumption and revenue declined, in consequence of the increase of duty in 1804; and the consumption has declined, in consequence of the succeeding augmentations, while the revenue has gained very little.‡ The duties on leather, after being stationary for nearly a century, were *doubled* in 1813. In 1812, the low duties produced L. 394,000; but, instead of being doubled, or of producing L. 788,000, when the tax was doubled, the annual revenue has scarcely ever since exceeded *half a million,* and has frequently fallen short of that sum.

Increase of the Duties on Wines.

The duties on foreign wines have been *tripled* since 1792. The last increase took place in 1815, when L. 30 *per* ton was added to the former duty on French, and L. 20 to that on Portuguese wine. Now, observe what has been the effect of this increase of duty. In the *Second Report* of the Lords' Committee on the Silk and Wine Trade (ordered by the House of Commons to be printed, 28th June 1821), a series of accounts are given, showing the quantity of wine imported into Great Britain, and re-exported, for a considerable number of years past, and the amount of the duties. From these accounts, we have drawn up the following Table of the number of tons of wine imported into Britain from 1809 to 1820, both inclusive; the number of tons re-exported during the same period; and the quantity remaining for home consumption.

	Tons imported.	Do. re-exported.	Remains for Home Consumption.	Average *annual* Consumption during the five years previous to 1815.
				Tons.
1809	49,762	14,501	35,261	
1810	47,058	12,729	34,329	
1811	20,787	5,928	14,864	28,489
1812	35,082	6,716	28,366	
§ 1813	—	—	—	
1814	31,465	11,838	29,627	
1815	30,874	5,855	25,019	Do. for five years subsequent to 1815.
1816	18,218	5,163	13,055	
1817	27,073	4,457	22,616	
1818	35,763	4,021	31,742	21,027
1819	23,408	3,843	19,565	
1820	22,782	4,625	18,157	
Average annual diminution of the consumption of wine for the five years subsequent to 1815, as compared with the five preceding years,				7,462

* Say, *Traité d'Economie Politique*, Tome II. p. 339. Lord Kames, in his *Sketches of the History of Man*, states, that these duties amounted to 48 *per cent. ad valorem.* Vol. II. p. 406. Edit. 1788.

† *Theory and Practice of Commerce*, Vol. II. p. 310. Eng. Trans.

‡ Mr Brougham's *Speech on the State of the Nation in* 1817, p. 54.

§ The *Records* for the year 1813 were destroyed by fire.

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Thus, it appears, that the increase of the duties on wine in 1815 has occasioned a diminution in the consumption of 7462 tons a year, or of ONE-FOURTH part of the total quantity annually consumed, on an average of the *five* years preceding the increase. Let us next see whether any augmentation of revenue has taken place to balance this diminution of the comforts of the people, and the loss of the market for the products which were previously exchanged for the wine.

From a Table in the same *Report* (p. 78), it appears that the produce of the duties of *excise* on the wines consumed in England from 1810 to 1820, both inclusive, has been as follows:

		Average *annual* duty for the five years previous to 1815.
1810	L. 1,406,417	
1811	1,215,507	
1812	1,065,159	L. 1,162,382
1813	1,061,604	
1814	1,065,223	
1815	1,277,481	
1816	943,987	Do. for the five years subsequent to 1815.
1817	928,473	
1818	1,195,427	L. 1,020,540
1819	1,085,500	
1820	949,328	

The *average* drawback, as given in the same Table, for the five years previous to 1815, is L. 63,674; and for the five years subsequent to 1815, L. 48,676; and, deducting these sums from the above, we have L. 1,098,708 for the amount of the average annual *excise* duty on wine for the five years preceding 1815; and L. 971,867 for the average annual amount of that duty for the five years after it had been increased about 20 *per cent.*; showing that the revenue, instead of being augmented, has sustained *a diminution of* L. 126,841 *a year by this increase of duty.*

The effect of the increase on the Custom duty has been equally striking. The accounts laid before Parliament do not go farther back than 1814; but in that year the *low* Custom duties amounted to L.1,061,416. In 1816, the *high* duties only amounted to L. 780,238; and except in 1818, when they amounted to L. 1,056,894, they have never since reached *one million.*

It is unnecessary to make any commentary on this decisive statement. The facts we have brought forward prove, beyond all question, that the revenue, the comforts of the people, and the commerce of the country, have all been *diminished* by this inordinate extension of the duties; and entitle us to conclude, that they would be all increased by their diminution.

Duties on Spirits.

There are, perhaps, no better objects of taxation than spirituous and fermented liquors, and none in which the injurious effects of over taxation are more striking and obvious. They are essentially luxuries; and while moderate duties on them are, in consequence of their being very generally used, exceedingly productive, the increase of price which they occasion has a tendency to limit their consumption by the poor, to whom, when taken in excess, they are extremely pernicious. Few governments, however, have been satisfied with the imposition of moderate duties on spirits; but, partly with the view of increasing the revenue, and partly with the view of placing them beyond the reach of the lower classes, they have almost invariably loaded them with such oppressively high duties as have entirely defeated both objects. The imposition of such duties does not take away the appetite for spirits; and as no vigilance of the officers, or severity of the laws, have been sufficient to secure a monopoly of the market to the legal distillers, the real effect of the high duties has been to throw the supply of a large portion of the demand into the hands of the illicit distiller, and to superadd the crimes and vices of the smuggler to those of the drunkard.

Increase of the Duties on Spirits in Ireland.

Nowhere, perhaps, have these injurious consequences of the excessive increase of spirit duties been more distinctly manifested than in Ireland. In proof of this, we may mention, on the authority of the *official* statements in the *Fifth Report** of the Commissioners of Inquiry into the State of Irish Revenue (p. 19), that in 1811, when the duty on spirits was 2s. 6d. *per* gallon, duty was paid in Ireland on 6,500,361 gallons; while in 1822, when the duty was 5s. 6d., only 2,950,647 gallons were brought to the charge. The commissioners estimate the annual consumption of spirits in Ireland at about *ten* millions of gallons; and as scarcely *three* millions pay duty, it follows that *upwards of* SEVEN *millions are illegally supplied;* and "taking *one* million of gallons as the quantity fraudulently furnished for consumption by the licensed distillers, the produce of the *unlicensed stills* may be estimated at *six millions of gallons!*" (p. 8.) It is material, too, to observe, that this extraordinary increase of smuggling took place in defiance of the utmost efforts of the revenue officers, police, and military, to prevent it. The only result of these efforts being the exasperation of the populace, and the committal of atrocities, both by them, and those employed in the collection of the revenue, that are hardly to be matched in the annals of civil warfare. "In Ireland," say the Commissioners, "it will appear, from the evidence annexed to this *Report*, that *parts of the country have been absolutely disorganized, and placed in opposition not only to the civil authority, but to the military force of the Government.* The profits to be obtained from the evasion of the law have been such as to encourage numerous individuals to persevere in these desperate pursuits, notwithstanding the risk of property and life with which they have been attended." (p. 1.)†

* Printed, by order of the House of Commons, 30th May 1823.

† The revenue and morals of no country, perhaps, have suffered so much from the injudicious extent to which taxes have been laid on commodities in general request as Ireland. This, however, is a subject on which our limits will not permit us to enter more at large; but our readers will find most of the necessary information in an article on High and Low Taxes in No. LXXII. of the *Edinburgh Review.*

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The too great height to which the duties were carried, and the injudicious mode in which they were charged and collected, produced similar effects in Scotland. The system of illicit distillation made great progress of late years, and had the most injurious influence on the morals and industry of the people in the mountainous districts, where it was principally carried on.

Increase of Spirit Duties in Scotland.

Reduction of the Spirit Duties in Ireland and Scotland.

Such having been the effects of their excessive increase, we have great satisfaction in stating, that the duties on both Scotch and Irish spirits have been reduced during the last session of Parliament (sess. 1822—23), from 5s. 6d. *per* gallon to 2s. 9d. Leave has also been given to use stills of a much smaller size,—a regulation which will have the effect of enabling minor capitalists to engage in the business of distillation, and which, by increasing competition, will tend both to improve the quality and to reduce the cost of the spirits. The country is indebted for this change of system to the recommendations in the excellent *Reports* of the Commissioners on Irish Revenue. It will certainly go far to suppress smuggling; and there is every reason to expect that the greatly increased consumption of *legally distilled* spirits, which the reduction of the duties will occasion, will make it have the same beneficial effects on the revenue as the reduction of duties in 1743 and 1787.

Duty on Spirits in England.

In England, the duty on spirits is as high as 10s. 6d. a gallon; and the trade in spirits between it and the other divisions of the empire is prohibited. This system is liable to many objections; but owing to the decided preference given by the lower classes in England to malt liquors over spirits, it has not given so great a stimulus to smuggling and illicit distillation as might have been expected.

The revenue collected within the United Kingdom on spirits distilled from grain, and the number of gallons on which it was paid in the year 1822, were respectively as follows:

	Revenue.	Gallons.
England	L.2,749,372	L.5,222,094
Scotland	687,467	2,499,880
Ireland...............	811,428	2,950,647
Totals...	L.3,248,267	L.10,672,621*

Salt Duty in France.

In France, previously to the Revolution, the average annual consumption of salt, in the provinces subjected to the *grande gabelle*, or high duty on salt, was estimated by M. Necker, who had the best means of coming to a correct conclusion, at $9\frac{1}{6}$ lib. to each individual; and at 18 libs. in the *pays redimées*, or provinces that had purchased an exemption from the greater part of this hateful tax. (*Administration des Finances*, Tom. II. p. 12.) It is evident, from this well authenticated statement, that a very great reduction might have been made from the duty paid on the salt consumed in the heavily taxed provinces, without occasioning any diminution of revenue; while, besides directly increasing the comforts of the people, it would have relieved Government from the necessity of surrounding particular provinces with cordons of troops, and would have put an instant stop to that smuggling of salt, which occasioned the sending of between 3000 and 4000 persons every year either to prison or to the gallies. (Arthur Young's *Travels in France*, Vol. I. p. 598.)

Taxation of different Countries.

SECT. V.—*Method of Comparing the Amount of Taxation in Different Countries—Circumstances which Depress the Rate of Profit—Its Fall in this Country rather a Consequence of the Corn Laws and of Tithes, than of Taxation.*

Amount of Population not a proper test of the ability of a Country to bear Taxes.

It has been usual to endeavour to ascertain the relative weight of the public burdens of different countries by comparing them with their population. But this is obviously a most false and erroneous criterion. In proof of this, we may observe, that, if the amount of population in a country were a true test of its capacity to bear taxes, it would follow that Ireland, which has a population of *seven* millions, could afford to pay three times the amount of the taxes paid by Scotland, which has only a population of *two* millions. So far, however, from this being the case, the actual revenue of Scotland is very little less than that of Ireland; and yet there is no reason whatever to think that the pressure of taxation is felt more severely here than amongst our neighbours.

Amount of Capital not a proper test.

The amount of the capital belonging to different countries has been suggested as a test by which to ascertain the relative weight of their burdens. But this would also lead to the most erroneous results; for, it is plain that a small capital in a country where profits are high may be more productive than a large one in a country where profits are low. The market rate of interest, which is always proportional to the customary rate of profit, is at this moment only about 4 or 5 *per cent.* in England, while it is not less than 8 or 10 *per cent.* in the United States. *One* million of capital laid out in America must, therefore, be about as productive, that is, it must yield about as large an annual income as *two* millions laid out in this country. And, hence it is obvious, that, if taxation, as compared with the amount of capital, were the same in both countries, it would, as compared with the profits on revenue derived from that capital, be about *twice as heavy* in England as in America.

The relative Taxation of Countries to be learned by comparing their Incomes with the number of their Inhabitants and their Burdens.

It is not, therefore, by the amount either of the population or the capital of a country, that its capacity to bear taxes is to be determined. Taxes, as we have already shown, really consist of a portion of the incomes of individuals transferred from the public to the State; and hence, to determine whether they are relatively higher or lower in one country than in another, it is necessary to ascertain the respective incomes of the States to be compared together, the number of their inhabitants, and the amount of their

* *Report on Distilleries*, p. 1.

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burdens. Supposing, for example, that the income of Great Britain, which has fourteen millions of inhabitants, is three hundred millions of pounds Sterling, which is believed to be very near its actual amount, and that its taxes, including poor rates, tithes, and public burdens of every description, amount to seventy millions, this sum deducted from the former would leave two hundred and thirty millions, which would give a free income of L. 16, 9s. a-year to every individual in the empire: Suppose, now, that the income of France is four hundred and fifty millions, and that the aggregate amount of her taxes, and public burdens of every description, is fifty millions, the four hundred millions of remainder, when divided among a population of thirty millions, would only leave a free income of L. 13, 6s. to each. There is good reason to think, that these estimates are not very wide of the mark: we do not, however, give them as being correct, for in such matters it is impossible to attain to any thing like accuracy; but as illustrations of the method to be followed in comparing the burdens laid on different countries; and as showing that, in proportion to her means of paying, a country with a small population, and a large absolute amount of taxes, may be really less heavily taxed than a country with a much larger population, and a smaller absolute amount of taxes.

Circumstances which have depressed the Rate of Profit.

The depression in the rate of profit—a depression which can only proceed either from heavy taxes on the necessaries of life, or from the effects of monopoly enhancing their price, or both—is by far the most unfavourable symptom in the economical situation of this country. The common and ordinary rate of profit is the sum which usually remains to those capitalists who employ their stock in productive businesses, after all their outlays, including a premium for the insurance of the capital itself, are compensated. It is by its amount, therefore, that the productive powers of industry are to be estimated. Wherever the rate of profit is relatively high, as in the United States, there is a proportional power of accumulation; and, provided the right of property be well secured, the capital, and, of course, also the population of the country, increase with comparative rapidity: But in countries such as Holland, where the rate of profit is relatively low, there is but little power of accumulation; and not only is their progress in wealth and population proportionally slow, but there is, besides, a very powerful motive to transmit capital to those countries where it is more productive. It is plainly, therefore, of the utmost consequence that the rate of profit, in every country, should be maintained at as high a level as possible. This, however, can only be effected by allowing the labourer to purchase his food in the cheapest market, and by exempting, as far as it can possibly be done, the necessaries of life from taxation: For we have shown, * that profits always vary inversely as wages—that they fall when wages rise, and rise when wages fall. Now, as the labourer must always have wherewithal to subsist and continue his race, it is plainly impossible to go on constantly adding to the price of the articles necessary for his subsistence, either by forcing him to purchase in dearer markets, or by loading them with taxes, without, at the same time, raising his wages and depressing profits. It is undoubtedly very difficult to say how much of the decline of the rate of profit in this country is to be ascribed to the effect of taxes laid on the necessaries of life, and how much to the corn-laws and other restrictive regulations. But that these laws must have a powerful influence in this respect is abundantly clear; for, in ordinary years, their effect is to maintain the price of corn in this country at nearly *double its elevation in any other country!* Tithes also contribute to raise the price of corn; and as corn, though not the sole, is the main regulator of wages, we are inclined to think that it is to the combined operation of the corn-laws and tithes that the decline in the rate of profit in this country is chiefly to be ascribed.

The taxes on tea, sugar, soap, candles, and beer, are those which, with the exception of tithes, fall heaviest on necessaries, and consequently exercise the greatest influence on profits. We think we are entitled to conclude, from the preceding investigations, that a very considerable reduction might be made in the amount of the duties affecting them, without occasioning any decrease, and even with a positive increase, of revenue. At all events, it is clear that the public interests imperiously require that every practical effort should be made to lighten the pressure on the national resources, and to check the efflux of capital to other countries, by adding to the productive powers of industry, or, in other words, by increasing the rate of profit. And this will be most effectually done by making every possible deduction from the taxes affecting necessaries, and by ceasing to bolster up and protect any single species of industry at the expence of the rest.

Tables illustrative of the progress of the public revenue of Great Britain have been given in Postlethwaite's and Sir John Sinclair's *Histories of the Revenue*, Chalmers's *Comparative Estimate*, Dr Colquhoun's *Treatise on the Wealth and Resources of the British Empire*, and a variety of other publications. We subjoin a copy of the Parliamentary paper (No. 157, Session 1822), which gives an account of the *gross* and *net* aggregate revenue of the united kingdom for the year ending 5th of January 1822, at the same time that it exhibits the amount of each separate branch of revenue in England, Scotland, and Ireland, and the expences of its collection. (s. s.)

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* Art. Political Economy in this *Supplement*, Part III. Sect. 5.

A Return of the Gross and Net Amount of the Revenue of the United Kingdom, in the year ending the 5th January 1822, for England and Wales, Scotland and Ireland; distinguishing each Country, and stating the Amount of the Charges of Management, and the Rate per cent. on the Gross and on the Net Receipt under each distinct Head of Revenue.

HEADS OF REVENUE.		GROSS REVENUE Accrued within the Year.			NET REVENUE Accrued within the Year.			CHARGES of MANAGEMENT.			Rate *per Centum* of Expence for Collecting the Gross Revenue.			Rate *per Centum* of Expence for Collecting the Net Revenue.		
		L.	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*
CUSTOMS,	England and Wales	11,845,789	19	8½	9,068,375	13	6	921,238	3	2	7	15	6	10	3	2
	Scotland -	759,796	7	9½	405,156	2	11	148,042	5	5	19	9	8	36	10	9
	Ireland -	2,184,118	17	8¾	1,586,167	9	9	410,307	1	10½	18	15	9	25	17	4
	United Kingdom -	14,789,705	5	2¾	11,059,699	6	2	1,479,587	10	5½	10	0	1	13	7	7
EXCISE,	England and Wales	27,406,561	3	9	24,822,559	11	8¼	964,515	19	4¾	3	10	5	3	17	9
	Scotland -	2,408,972	0	2¾	2,035,401	11	7	169,403	18	11½	7	0	8	8	6	5
	Ireland - -	1,997,452	9	9½	1,668,004	7	5¾	287,048	13	1	14	7	5	17	4	2
	United Kingdom -	31,812,985	13	9¼	28,525,965	10	9	1,420,968	11	5¼	4	9	4	4	19	8
STAMPS,	England and Wales	6,146,537	5	4	5,785,708	8	1¾	151,225	1	10¾	2	9	2	2	12	3
	Scotland -	480,274	5	1½	438,172	5	7½	32,542	11	3	6	15	6	7	8	6
	Ireland - -	452,159	2	1¾	398,602	3	7½	42,312	13	3½	9	7	2	10	12	3
	United Kingdom -	7,078,970	12	7¼	6,622,482	17	4¾	226,080	6	5¼	3	3	10	3	8	3
LAND & ASSESSED TAXES,	Eng. & Wales	7,210,058	0	10	6,910,672	7	5¼	299,385	13	4¾	4	3	1	4	6	8
	Scotland -	470,311	2	5½	432,223	13	6½	38,087	8	11	8	2	0	8	16	3
	Ireland -	361,935	1	9¼	308,486	11	1¼	53,448	10	8	14	15	4	17	6	7
	United Kingdom	8,042,304	5	0¾	7,651,382	12	1	390,921	12	11¾	4	17	3	5	2	2
POST OFFICE,	England & Wales	1,700,933	19	8¾	1,204,188	10	10	468,578	8	10	27	11	0	38	18	3
	Scotland -	168,250	10	7	120,855	6	0½	47,395	4	6½	28	3	5	39	4	4
	Ireland -	175,618	6	1¼	68,187	18	9½	101,082	8	9¾	57	11	2	148	4	10
	United Kingdom	2,044,802	16	5	1,393,231	15	8	617,056	2	2¼	30	3	6	44	5	9
One Shilling and Sixpence Duty, and Duty on Pensions and Salaries.	England and Wales	74,409	1	6¾	72,469	8	10¾	1,939	12	8	2	12	2	2	13	6
	Scotland -	4,963	2	11	4,833	2	11	130	0	0	2	12	5	2	13	10
	Ireland -	—			—			—			—			—		
	United Kingdom	79,372	4	5¾	77,302	11	9¾	2,069	12	8	2	12	2	2	13	7
Hackney Coaches - -		26,248	2	6	22,148	11	7	4,099	10	11	15	12	5	18	10	3
Hawkers and Pedlars - -		31,655	3	3	25,817	19	0	5,837	4	3	18	8	9	22	12	2
Poundage Fees -	Ireland	4,269	13	11¾	4,269	13	11¾	—			—			—		
Pells Fees - -	Do.	853	18	5¾	853	18	5¾	—			—			—		
Casualties - -	Do.	3,815	15	9½	3,815	15	9½	—			—			—		
Treasury Fees and Hospital Fees	Do.	985	4	4$\frac{3}{1}$	985	4	4¾	—			—			—		
Small Branches of the Hereditary Revenue.	Alienation Fines -	11,255	10	0	10,108	2	0	1,147	8	0						
	Post Fines -	685	10	0¾	610	2	8¾	75	7	4						
	Seizures, Compositions, Proffers, &c. &c. -	4,154	19	9	4,154	19	9	-	-	-	4	2	8	4	6	2
	Crown Lands -	106,621	13	8	102,773	8	11½	3,848	4	8½						
TOTAL of ORDINARY REVENUES		64,038,686	9	5¼	55,505,602	10	6½	4,151,691	11	4½	6	9	8	7	9	7
EXTRAORDINARY RESOURCES		745,774	0	4¾	735,632	5	9¾	10,141	14	7	—			—		
TOTAL PUBLIC INCOME OF THE UNITED KINGDOM (exclusive of Loans)		64,784,460	9	10	56,241,234	16	4¼	4,161,833	5	11½	—			—		

Taxation || Telegraph.

Abstract of the Preceding Account.

	GROSS REVENUE Accrued within the Year.			NET REVENUE Accrued within the Year.			CHARGES of MANAGEMENT.			Rate *per Centum* of expence for Collecting					
										The Gross Revenue.			The Net Revenue.		
	L.	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*	*L.*	*s.*	*d.*
England and Wales -	54,564,910	10	$1\frac{3}{4}$	48,029,587	4	$6\frac{1}{4}$	2,821,890	14	$6\frac{3}{4}$	5	3	5	5	17	6
Scotland - -	4,292,567	9	$1\frac{1}{4}$	3,436,642	2	$7\frac{1}{2}$	435,601	9	1	10	2	11	12	13	6
Ireland - -	5,181,208	10	$2\frac{1}{4}$	4,039,373	3	$4\frac{3}{4}$	894,199	7	$8\frac{3}{4}$	17	5	2	22	2	9
Total Ordinary Revenues of the United Kingdom	64,038,686	9	$5\frac{1}{4}$	55,505,602	10	$6\frac{1}{2}$	4,151,691	11	$4\frac{1}{2}$	6	9	8	7	9	7
Extraordinary Resources	745,774	0	$4\frac{3}{4}$	735,632	5	$9\frac{3}{4}$	10,141	14	7	—			—		
Total Public Income of the United Kingdom (exclusive of Loans)	64,784,460	9	10	56,241,234	16	$4\frac{1}{4}$	4,161,833	5	$11\frac{1}{2}$	—			—		

TELEGRAPH.

Telegraph, so named from two Greek words, τέλος, end or distance, and γϱαφω, to write, is a machine so constructed as to enable two persons to converse with each other at a distance, either by sentences, words, or letters, according to a convention previously agreed upon by the parties. Such a mode of communicating ideas beyond the reach of hearing is not, however, confined to any particular machine; the fingers of the human hand are quite sufficient, as every young boarding-school lady knows, for the purpose; and, when so applied, may be called a *Telegraph.* Thus also, the signal flags used on board ships to communicate with each other, by making them represent letters or numbers, or both, constitute a *Telegraph;* as may also the sending up of sky-rockets, blue-lights, the suspension of lanterns, the making of fires on beacons, high hills, &c. be considered as Telegraphic communications.

In imitation of the French, however, we have almost indiscriminately adopted the use of the word *Semaphore* for the Telegraph, which is perhaps of more extensive application, being derived from σημα, *a sign*, and φέϱω, to bear; and may, consequently, be applied universally to whatever means may be used to communicate intelligence by signs or signals. Thus the firing of guns a certain number of times, at certain intervals,—the notes of a trumpet, bugle, French horn, or other wind instrument,—the strokes on a drum,—may be used to convey information to a limited extent. The troops and marines which landed on the coast of America in the last war, when scouring the woods in detached parties, were regulated by the notes of the bugle, which were so clearly understood, that no false movements were ever made. The immense number of barges and boats which crowd the Imperial Canal of China are directed in their movements, both by night and day, by the sound of the *gong.* The Indians of America convey intelligence from hill to hill, by throwing out their arms with or without staves in them; by spreading their cloaks, holding up skins, &c.; and even the savage Hottentots, called Bosjeismans, the lowest probably in the scale of human beings, communicate with each other by arranging fires on the sides of the hills in certain positions.

It is rather surprising that an art so simple as that of conveying ideas by means of signals, so well understood in remote antiquity, and practised even by savages, should have made such little progress in its improvement, that it may be said to have remained in its original rude state nearly down to our own times, when it has almost at once been brought to that state of perfection, of which it appears to be capable.

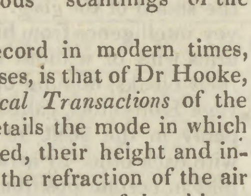
One of the arguments usually adopted to prove that the art of conveying intelligence by signals was known in the very early ages of Greece, is deduced from the opening of the *Agamemnon* of Æschylus, where the man on the watch-tower, at the top of the palace, announces the fire-signals having communicated the fall of Troy, long before any of the Greeks had returned from the siege; and Clytemnestra afterwards relates the stations; but this event of the burning of Troy, supposed thus to have been known in Greece soon after it happened, proves nothing more than that the use of signals was known to the poet who wrote eight or nine hundred years after the event. Mention, however, is made by Jeremiah (Ch. vi. v. 1), who was at least 200 years before

Æschylus, of "setting up a sign of fire in Beth-haccerem;" and such signals are often alluded to by the prophets, as notices of the approach of an enemy.

The earliest decisive proof of telegraphic communications, except those by fires (πυρσεῖαι), being in use among the Greeks, is found in the methods described by Polybius. (See *Ency. Brit.* under word Telegraph.) The Romans had their *vexillarii*, and used flags and other contrivances for regulating the movements of their armies; and they had hollow tubes constructed in the walls of their cities, by which they could communicate with the several ports or works by sound, as is done in our times in some manufactories by means of pipes or trumpets. Wherever the Romans pitched their camp, an elevated spot was selected for the signal station, to convey intelligence to the foraging parties or detachments, but it is nowhere stated to what extent this was carried. Vegetius alludes to something like a beam in the air, on the same principle perhaps as our Semaphore.

In modern times, Kircher, who had more learning and less sense than any man of his day, and who has written on almost every subject, gives an idea of telegraphic communication; and so does the ingenious Marquis of Worcester, in his *Century of Inventions;* but so vague as to convey no notion of the means he was to employ, except the use of *colour*; for the "discourse" to be held, is stated to be "as far as eye can discover black from white." He also throws out a hint for a night telegraph, by which the same may be done, "though as dark as pitch is black." But almost every modern invention is supposed to exist in the mysterious "scantlings" of the Marquis of Worcester.

The first telegraph on record in modern times, applicable to universal purposes, is that of Dr Hooke, described in the *Philosophical Transactions* of the year 1684. He minutely details the mode in which the stations should be selected, their height and intermediate ground, so that the refraction of the air may not disturb the clear appearance of the object; the telescopes to be used; the characters to represent the alphabet, which, he says, may be varied ten thousand ways, and "none but the two extreme correspondents shall be able to discover the information conveyed:" and so convinced is he of the practical efficiency of his telegraph, as to leave no doubt on his mind, "that the same character may be seen at Paris within a minute after it hath been exposed in London." His method consisted in exposing in succession as many different shaped figures or signs, at least, as the alphabet consists of letters. If used in the day-time, they might be squares, circles, triangles, &c. made of deals; if at night, torches or other lights disposed in a certain order. These characters or signs were to be brought forth from behind a screen on rods, as they might be wanted, and exposed to view. The accompanying figure, where A is the screen, and ⊓ one of the signs exhibited, will convey an idea of Dr Hooke's telegraph.

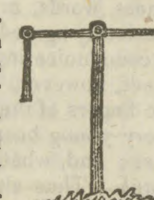


Monsieur Amantons, of the Royal Academy of Paris, made an experiment to convey intelligence, which was highly approved of by the other members, and several persons of distinction belonging to the Court. By the description given of the machine, it seems to have differed very little from that of Hooke already published in the *Philosophical Transactions;* the signals being either large letters of the alphabet, or figures of various shapes to represent them; the latter being the more valuable, as, by a change of key, the nature of the communication might be kept a secret from those actually employed in making the signals.

It has been supposed that electricity might be the means of conveying intelligence, by passing given numbers of sparks through an insulated wire in given spaces of time. A gentleman of the name of Ronalds has written a small treatise on the subject; and several persons on the Continent and in England have made experiments on Galvanic or Voltaic telegraphs, by passing the stream at the two extremities or stations through phials of water; but there is reason to think that, ingenious as the experiments are, they are not likely ever to become practically useful.

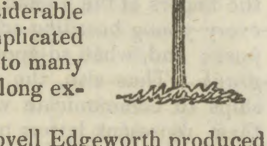
Necessity is said to be the mother of invention; she is also frequently the foster-mother, who calls forth into action, and displays the utility of, inventions abandoned by their natural parent. Both Hooke's invention and Amantons' modification were published all over Europe, the former as early as 1684; yet they were not practically applied to any useful purpose till the year 1794, when Citizen Barrere, in a report made to the Convention, ascribed the invention then in use to Citizen Chappe.

Chappe's telegraph consists of a beam of wood, moveable on a pivot at the summit of an upright post; at each of the extremities of this beam is a moveable arm, as in the figure. The different positions in which both the beam and its two arms may be placed at angles of 45° give to this telegraph considerable powers; but it is a too complicated machine not to be liable to many mistakes, unless worked by long experienced operators.



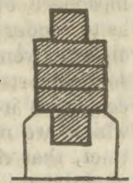
In the year 1784, Mr Lovell Edgeworth produced his plan of a numerical telegraph, claiming, at the same time, the merit of having invented a mode of distant communication as far back as 1767, by employing a common windmill, and arranging the various positions of its arms and sails so as to represent a certain number of signals arranged in numerical order.

Mr Edgeworth's telegraph consisted of four wedges or cones, moveable on four upright posts, as under, which, by their different positions, might be used either numerically or alphabetically.



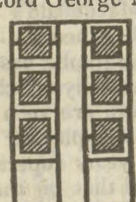
In the year 1795, when the advantages had been made evident which the French derived from M. Chappe's telegraph, the inventive faculties of our countrymen were called into action. Among other proposals, the Rev. J. Gamble produced two plans of a telegraph; the one consisting of five boards, one above the other, which, by opening and shutting singly, or according to all the combinations of which they were capable, gave

a certain number of distinct signals, representing either numbers or letters, as might be deemed most expedient. The arrangement of the shutters was as in this figure. The other plan was that of five beams of wood, turning on the summit of a post, so as to form five radii of a semicircle at equal angles of 45° with each other, as under.



Among other projects about this time was that of dividing a large circle into twenty-four parts, to represent the letters of the alphabet, round which a moveable radius was to traverse; then, by placing corresponding divisions, by means of wires, before the object-glass of the telescope, the coincidence of the two radii would mark out the letter meant to be designated. Of this kind, a plan by Mr Garnet approached nearest to efficiency; but, at best, could only be applied to very short distances.

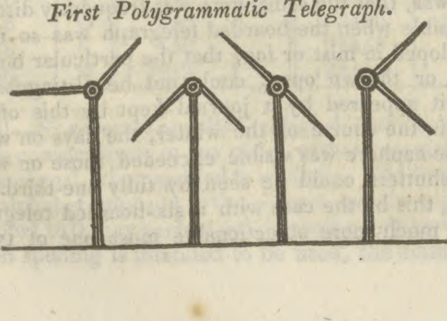
In the same year (1795), Lord George Murray presented his plan of a six-shutter telegraph to the Admiralty, which was the one adopted and made use of during the whole war, and until the year 1816, when it was changed for a simplified Semaphore, which will be noticed hereafter. The annexed figure represents that of Lord George Murray.



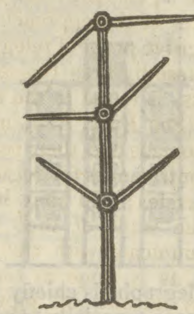
On the same principle as the radiated telegraph of Mr Gamble, but differently arranged, the French, on the commencement of the second war in 1803, erected signal-posts along the coast, to which they gave the name of Semaphores, being two or three beams of wood on the same post, but turning on different pivots.

In 1807, Captain (now Colonel) Pasley published his *Polygrammatic Telegraph*, which differed only from the French Semaphore in having two beams turning on one pivot on the same post, and multiplying the number of posts; which he afterwards (in 1810) changed so far as to place three sets of beams or arms, two in each set, on one post, and thus approaching still nearer to the French Semaphore.

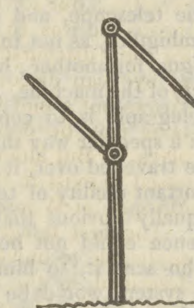
First Polygrammatic Telegraph.



Second Polygrammatic Telegraph.

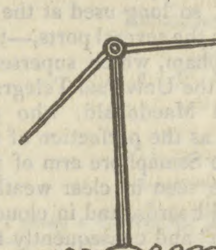


In the year 1816, Sir Home Popham, who had already introduced a new code of signals into the navy, which was admitted on all hands as a great improvement on the old system, both as regarding the number, the arrangement, and the shape of the flags, now turned his attention to the land Semaphore, and proposed one on a construction of the same nature with those of M. Chappe and Colonel Pasley, but much simplified. It was, in fact, nothing more than two moveable arms on separate pivots on the same mast, as under.



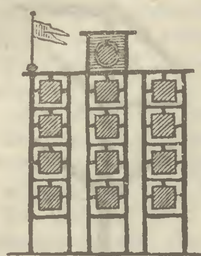
This machine, on account of its simplicity, had obviously the advantage over all others that had been proposed; and being found of sufficient power and efficiency for all required purposes, it was adopted by the Admiralty, instead of the shutter telegraph, which had been in use since the year 1795.

Colonel Pasley, however, in 1822, still farther simplified this useful machine, at the expence of sacrificing a small portion of its powers, by making the two arms revolve on the same pivot, as under, to which he has given the name of the "Universal Telegraph."



The last, but by far the most persevering and voluminous writer on telegraphs, is Lieut.-Colonel Macdonald, who, in 1808, published what he deems improvements in the system of telegraphic communications, both as they regard the machine itself, and the dictionary to be used with it. He not only gives the preference, but is so much attached, to the shutter machine, that he is quite indignant at its being supplanted by the Semaphore; and so far from being satisfied with the powers of which a six-shutter telegraph is capable, he has extended his to no less than *thir-*

Telegraph. teen different boards, as under, by which he certainly gains power enough, but not without producing confusion and perplexity.



As the use of telegraphs is chiefly confined to public purposes, and more especially to convey speedy information respecting naval and military armaments and operations, the machine to be adopted, and the system of working it, ought to possess—*power*—*certainty*—*simplicity*—*celerity*—and *secrecy*. The *power* of the machine, or the number of distinct combinations of its moveable parts, should be equal to the conveyance of every possible order or information, either by numbers, representing the letters of the alphabet, or words, or sentences. To ensure *certainty*, the moveable parts or signs should be so well and clearly defined, so wholly within the field of the telescope, and so completely removed from all ambiguity, as not to be liable to the mistaking of one signal for another; hence, the advantage of the *simplicity* of the machine. And as one of the main uses of the telegraph is to convey instructions or intelligence in a speedier way than the intermediate distance can be travelled over, it is evident, that *celerity* is an important quality of telegraphic communication. It is equally obvious that, if such instructions or intelligence could not be conveyed in *secrecy* from him who sent it, to him who was to receive it, such a system would be highly defective and objectionable.

Bearing these observations in mind, we shall not have much difficulty in determining on the merits of the several telegraphic machines above mentioned. The choice, indeed, appears to lie between the six-shutter telegraph, so long used at the Admiralty, to communicate with the several ports,—the Semaphore of Sir Home Popham, which superseded it, and is now in use,—and the Universal Telegraph of Colonel Pasley. Colonel Macdonald, who conceives the shutter telegraph as the perfection of the art, boldly asserts, that "the Semaphore arm of proper dimensions is not to be seen in clear weather so well as the common sized boards, and in cloudy weather by no means so well;" and consequently that, "for this climate, the boarded telegraph is, in all respects, more advantageous." This would be important if correct; but it is evident, that the Colonel is not aware of the discussion which took place on this very important part of the subject, on the first adoption of the *boarded* telegraph; had he read the clear and decisive observations of Mr Gamble, he would scarcely have ventured upon such an assertion.

"It is a theorem in optics," says Mr Gamble, "that the apparent magnitude of an object varies nearly in the inverse ratio of its distance. Hence, it follows, that the larger its dimensions, to the greater distance will it be visible. But the nature of our atmosphere, even in its most transparent state, is such as to render any calculation, grounded on this principle, extremely erroneous; and in general its density so obstructs, and its refracting powers cause such confusion in, the rays issuing from those surfaces which are not placed sufficiently distant to be distinct, that their image falling upon the retina is frequently so ill defined, as to render it difficult to determine either their figure or position; for which reasons, that which I shall term *insulation*, is generally a quality more requisite to give *distinctness* to an object, than magnitude of superficial dimensions." Telegraph.

This is unquestionably true; but Mr Gamble illustrates his position thus: "An example of this distinctness arising from insulation cannot be more readily obtained than by taking a page of printed paper, and fixing the eye on some particular letter (as I); then retiring from it, the letter will be so confused with the surrounding ones, as not to be easily distinguished: but if the same letter (I) be printed on a plain sheet of paper, standing by itself (or *insulated*), the eye will then not only discern it at a much greater distance, but the image falling single and unencumbered upon the retina, we shall be able to determine whether it be inclined to the right or to the left, or whether it be placed horizontally on the paper."

The shutter telegraph is the printed page, and the arm of the semaphore is the letter (I) on a plain sheet of paper.

But actual experiment has completely proved the fallacy of Colonel Macdonald's assertion, and the justice of Mr Gamble's theory. Every officer serving on the line of telegraphs has stated, that at all times, and more especially in cloudy weather, the arms of the semaphore are seen much better than the boards of the telegraph ever were. Lieutenant Pace, who for many years superintended the Admiralty station, declared that on the first day after the West Square semaphore was erected, he could clearly distinguish the positions of the arms *without a telescope*, and accurately take down any signals that could be made, which he had never been able to do under any circumstance whatever with the shutter telegraph. He also stated that he had frequently an open communication with the semaphore at West Square, whilst St Paul's was capt by a fog, which was at all times considered by him and his assistant as the conclusive sign that the boarded telegraph could not be worked. But in order to set the matter entirely at rest, the shutter telegraph on Nunhead, near Newcross, was left standing on the same hill with the new semaphore, in order to try their comparative distinctness, for a whole winter. The result was, that the semaphore was frequently distinctly visible when the boarded telegraph was so much enveloped in mist or fog, that the particular boards, shut or thrown open, could not be distinguished: and it appeared by a journal kept by this officer, that in the course of the winter, the days on which the semaphore was visible exceeded those on which the shutters could be seen by fully one-third. If, then, this be the case with a six-boarded telegraph, how much more objectionable must one of twelve

Telegraph.

shutters be, which must necessarily be placed so near to each other as to make it at all times a matter of difficulty to discern at once how many, and which of them, are closed, and which open? Even in the six-shutter telegraph, one board has frequently been mistaken for the other: for it may be remarked, that such a mass of timber as is required for a shutter telegraph is seldom free from haze.

It will probably be urged, that the arms of the semaphore, having to describe a larger circle, must be slower in their operations; but this increased slowness is so amply compensated by the ease and certainty of reading off the signals as to render any such objection of little or no weight: it may make the difference of *one second* in each signal, whilst the machinery by which the semaphore is worked is as simple and as little liable to be out of order as that of the boarded telegraph.

The six-shutter telegraph, it is true, has greater powers than the two-armed semaphore, and much greater than the universal semaphore of Colonel Pasley; that is to say, the number of combinations of which it is capable of making without using the *stop*-signal (or signal which separates one word, or one sentence, from another), is much greater than in either of the other two; but *all* of them have sufficient powers, and a sufficient number of combinations, to convey with facility and dispatch any communication whatsoever, and in any language, either by letters, words, or sentences. Their respective powers may be seen by the following tables of their positions.

Admiralty Six-shutter Telegraph.

No. of Signal, or of Shutters closed.	Signification.	No. of Signal, or of Shutters closed.	Signification.	No. of Signal, or of Shutters closed.	Signification.
1	A	123	9	1235	
2	Z	124	6	1236	
3	X	125	5	1245	
4	W	126	4	1246	
5	B	134	0	1256	
6	F	135	1	1345	
12	L	136	2	1346	
13	O	145	6	1356	
14	V	146	3	1456	
15	U	156	8	2345	
16	H	234	G	2346	
23	Qu	235	C	2356	
24	R	236	D	2456	
25	T	245	E	3456	
26	S	246	Y	12345	
34	P	256		12346	
35	N	345		12356	
36	I	346		12456	
45	O	356		13456	
46	K	456		23456	
56	M	1234		123456	

In all—62 separate and distinct signals; which may be made consecutively in any order, without requiring any *stop*-signal, when applied to spelling. The letters of the alphabet opposite to the signals, and the numbers from 1 to 0, may be changed in every possible way.

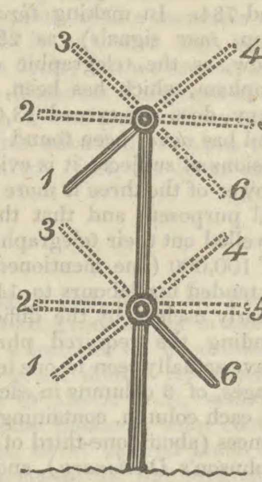
When spelling is intended to be used, the number of changes need not of course exceed that of the alphabet; the rest, as in the table, may be applied to numbers; and what still remains may be made to represent *words* that are most commonly in use; as, for instance, *admiral, captain, ship of the line, frigate, arrived, sailed, harbour,* &c. in the navy; or, if military, *general, regiment, camp,* &c.

Admiralty Semaphore now in use.

No. of Signal by 1 and 2 Arms.	Signification.	No. of Signal by 1 and 2 Arms.	Signification.	No. of Signal by 1 and 2 Arms.	Signification.
1	1	15	G	43	X
2	2	16	H	44	Y
3	3	21	I	45	Z
4	4	22	K	46	
5	5	23	L	51	
6	6	24	M	52	
1	A	25	N	53	
2	B	26	O	54	
3	C	31	P	55	
4	D	32	Qu	56	
5	E	33	R	61	
6	F	34	S	62	
11	7	35	T	63	
12	8	36	U	64	
13	9	41	V	65	
14	0	42	W	66	

In all—48 separate and distinct signals; being the whole which the two arms are capable of making, as under; in which the two arms actually exhibited (in black lines) represesent the number 16 or H, according to the table or *key*, as above arranged.

We have here, in addition to the alphabet and the numeral digits, 13 signs over, applicable to the names of stations, preparative, finish, stop-signals, &c.

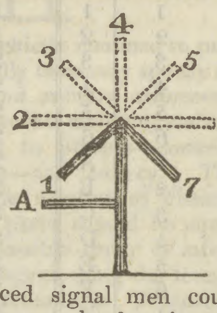


Colonel Pasley's Universal Telegraph.

No. of Signals.	Signification.	No. of Signals.	Signification.	No. of Signals.	Signification.
1	A	15	L	36	V
2	B	16	M	37	W
3	C	17	N	45	X
4	D	23	O	46	Y
5	E	24	P	47	Z
6	F	25	Qu	56	
7	G	26	R	57	
12	H	27	S	67	
13	I	34	T		
14	K	35	U		

In all—28 separate and distinct signals; containing a sufficient number for expresssing the letters of the alphabet, and, consequently, for spelling any message; but not a sufficient number left to express the numeral digits by single signs. The signal, No. 4, is besides, as Colonel Pasley is aware, liable to be mistaken, it being a mere elongation of the mast, which, at a great distance, and owing to the refractive power of the atmosphere, will always be ambiguous when exhibited as a single signal. But Colonel Pasley has added a short arm which he calls an *indicator*, as below at A; and which, when made moveable, more than compensates for this defect.

It was with a different view, however, that he has added this indicator. It was suggested to him by a Captain in the navy, who had experienced the greatest inconvenience, in using Sir Home Popham's ship Semaphores, from the signal men confounding the positions of the arms when seen in *reverse*.



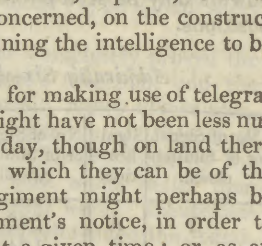
We apprehend no experienced signal men could possibly make any mistake in merely changing the right hand for the left.

The respective powers of the three telegraphs, in making single, or, what may be called, primary signals, are, as appears from the tables, 62, 42, and 28. In making *two* changes, with a stop between them (that is, *three* signals) to represent a word or sentence, their powers will be as 3844, 1764, and 784. In making *three* changes (or, with the stop, *four* signals), as 238,328—74,088—21,952. Now, as the telegraphic dictionary of Sir Home Popham, which has been, and still is, used in the navy, does not exceed 13,000 words and sentences, and has never been found deficient in any of its divisions of subjects, it is evident that even the lowest power of the three is more than sufficient for all useful purposes; and that those compilers, who have swelled out their telegraphic dictionaries to upwards of 100,000 (one mentioned by Colonel Pasley has extended his labours to 140,000), have made them nearly useless, by the difficulty and loss of time, in finding the required phrase or sentence. We have actually seen in one telegraphic dictionary 126 pages, of 3 columns in each page, and 60 sentences in each column, containing upwards of 20,000 sentences (about one-third of the number of words in Johnson's *Dictionary)*, and each of these sentences beginning with the personal pronoun HE; 20 pages with IF, &c. Compared with the use of such a dictionary, spelling the sentences is infinitely preferable as to certainty, and in many cases as to celerity. Indeed, we should say that the abbreviated nature of communications made by telegraph renders spelling by far the most elegible mode. In clear weather, the rapidity of working single signals, the short compass within which any message may be condensed, the impossibility of committing any mistake that cannot be immediately rectified, more than compensates for the difference of a few minutes, which the use of sentences may probably save. In cloudy or foggy weather, the latter method will always be liable to mistake. If experience may be assumed as a guide, the practice at the Admiralty, of spelling all sentences for the last thirty years, must decide in favour of that system.

In making use of the alphabetical table, much time may be saved, by condensing the message into the briefest form possible, leaving out of the sentences such words as may not alter the sense, and generally the vowels of words. For instance, "*Order the Agamemnon out of harbour, and direct her to proceed to Spithead.*" To convey this message alphabetically, it would be quite enough to say, "Agmemn to Spthed." If *from Spithead into harbour*, "Agmemn nto hrbr." In spelling, too, it is very desirable, especially in our foggy climate, that the intelligence to be conveyed should be compressed as much as possible into the early part of the message. By not observing this rule, a curious mistake is said to have been made in the course of the Peninsular war. The Admiral at Plymouth endeavoured to send up a message, but a fog coming on, part of it only on that day reached London. It began thus: "Wellington defeated"—and the rest was stopped by the fog: the anxiety for the remainder may readily be conceived; it came, however, complete towards the evening, and conveyed the intelligence, that "Wellington defeated the French," &c. Had the message been thus framed, "French defeated at," &c. (the word Wellington being quite superfluous), the anxicty for the particulars would have been of a very different kind. Much, therefore, depends, as far as celerity and certainty is concerned, on the construction of the sentence containing the intelligence to be conveyed.

The methods suggested for making use of telegraphic communicatious by night have not been less numerous than those for the day, though on land there are very few occasions on which they can be of the least possible use. A regiment might perhaps be ordered to move, at a moment's notice, in order to reach a particular point at a given time; or, as an extreme case, the enemy's fleet might be seen towards the close of the day in a particular quarter, which would make it desirable to have the intelligence conveyed in various directions; but no naval movement could take place during the night at any of the ports. So little useful, indeed, does a night telegraph, for the navy, appear to have been considered, that, with all the facility of applying lamps to the shutter-telegraph at the Admiralty, no attempt was ever made for carrying such a purpose into execution. Colonel Pasley's description of the application of his *Universal Telegraph* to night signals will suffice to show one method (as good as any other perhaps) of adopting the machine to this purpose.

"For night signals, one lantern, called the centre light, is fixed to the top of the post; and one lantern (I) as an indicator is fixed to a light crane or derrick, attached to the post, by night only, as under.



"These lanterns are stationary, and appear on the same level. Two other lan-

terns are suspended to the ends of the arms, upon fixing which a couple of weights are added to counterpoise them. Each of the two arms by day, and each of the two moveable lights by night, is capable of exhibiting the seven positions, besides position O pointing vertically downwards. The indicator serves to distinguish the low numbers 1, 2, 3, from the high numbers 7, 6, 5, in whatever direction the telegraph may be viewed."

The use of telegraphic communication, important as it may be on land, is far more so in the management of a fleet at sea. On the unfortunate result of Admiral Keppel's engagement, Dr Beatson, in his *Memoirs*, thus expresses himself:—"The defects or impropriety of the signals having thus appeared clearly to be the true and sole cause of the miscarriage which disappointed the reasonable hopes of Britain on this critical and weighty occasion; we may be justified in observing, that if an admiral cannot command all the necessary movements of his ships by signal on the day of battle, he is not upon a footing with an enemy who possesses that advantage; and even with better ships and better men, and more experienced commanders, he may be foiled in his expectations of victory, if not defeated, from his want of the means to direct and to perform the necessary evolutions of his fleet."

In the *Fighting and Sailing Instructions* of the Duke of York (afterwards James II.), a certain number of signals are established for certain movements and manœuvres of the fleet, each flag or flags having their respective objects. The *l'Art des Armées Navales* of le P. l'Hoste, published at Lyons in 1697, contains something like a system of signals, but so awkward and clumsy, as to be of a very limited use. Indeed, the best signals made use of, down to the American war, could only be considered as expedients; the *numerical plan* having never once been attempted, though Dr Hooke, De la Bourdonnois, and some others, had long before suggested it.

In 1798 a new signal-book was issued by the Admiralty, containing about 400 sentences, for which flags were appropriated numerically, expressive of certain operations of a fleet, which were sufficiently useful as far as these sentences went; but when it became necessary to issue any order not to be found among them, the communication was obliged to be made by boats—and "a boat from each ship" was ordered. The state of the weather did not always render this practicable; and when it was, men's lives were frequently exposed to imminent risk. To remedy this inconvenience, Sir Home Popham printed at Calcutta a numerical code of naval signals, which was reprinted in England in 1803. He afterwards extended the code very considerably, which, by a recommendation of a committee of naval officers, has been adopted, and is now in general use in the navy. The only objection to this code, which more or less applies to all that have subsequently been proposed, is the great number of flags, &c. required for making numerical signals to the extent as laid down in the code in question; and which consists of nine flags, five cornettes, five triangles, and five pendants. With such a number, it is next to impossible to make out, in calm weather, the *figure* and the *colour* of the flags; and equally so when in situations where, though expanded by the wind, they present only an *edge* to the eye of the observer when the distance is not too great, so as to sink the hull of the ship behind the curvature of the earth. The semaphore or sea telegraph of Sir Home Popham comes in aid of, and indeed entirely removes, those difficulties. It consists of two posts, with a moveable arm to each (see the article NAVY), and may be removed to any part of the deck; but we are not sure, simple as it is, that the *Universal Telegraph* of Colonel Pasley, consisting of one post and two arms, might not be adopted with advantage as a sea telegraph. The former exhibits *eight*, the latter *seven* positions. (K.)

TENNANT (SMITHSON), a distinguished Chemist, born at Selby, in Yorkshire, 30th November 1761; was the only child of the Rev. Calvert Tennant, younger son of a respectable family in Wensley Dale, near Richmond, and vicar of Selby; his mother was Mary Daunt, daughter of a surgeon of that town.

His father had been a fellow of St John's College, Cambridge, and began to teach his son Greek when he was only five years old. He had the misfortune to lose him four years after; and before he grew up, his mother also, while he was riding with her, was thrown from her horse and killed on the spot. He was sent, after his father's death, to different schools, at Scerton, Tadcaster, and Beverley; in these he was remembered as a boy retired in his manners, and somewhat melancholy, and indolent with respect to puerile amusements. He learned but little at school, and may be considered as in great measure self-educated; having been fond, almost as a child, of reading books of science, and of amusing himself with little experiments which he found described in them; and while he was at school at Tadcaster, he took great delight in attending a course of Walker's lectures on experimental philosophy which were given there. At Beverley he was under the care of Dr G. Croft, who had made himself known to the public by some controversial writings; here he never entered much into the pursuits of his contemporaries, but profited by a good library belonging to the school; and among other books which he read with avidity was Sir Isaac Newton's *Treatise on Optics*.

He had entertained a great desire to complete his chemical studies under the immediate instruction of Dr Priestley, who was then enjoying deserved reputation for his recent experimental discoveries; but Dr Priestley's occupations did not permit him to undertake the task of directing his education, however agreeable it might have been to him to have assisted such a pupil. In the meantime he had not neglected his classics, but had acquired a sufficient knowledge of the learned languages to appreciate with correct taste the beauties of the great writers of antiquity.

Tennant.

Notwithstanding his admiration for Dr Priestley, he was an early convert to the antiphlogistic theory of chemistry; which, with all its errors, was still a material step in the advancement of science.

In 1781 he went to Edinburgh, with the view of qualifying himself for the profession of physic, and he had the advantage of attending Dr Black's lectures, which were then in great reputation. In October 1782, he entered as a pensioner of Christ's College, Cambridge, where he became intimately acquainted with the late Professor Harwood, who had been first a surgeon in India, but having lost, by the misconduct of an agent, the fortune that he had there acquired, submitted cheerfully to the toil of recommencing his career as a physician, though already past the middle age: his talents for conversation were such as were extremely likely to captivate a young man of superior discernment; and he formed a friendship with Tennant which continued uninterrupted throughout their lives.

At Cambridge he studied a little of the mathematics, in the works of Newton, but much more of chemistry and botany: he already began to exercise his inventive powers in an attempt to economize the consumption of fuel in distillation, which he did not make public until 20 years after, though he mentioned it at the time to some of his friends. He also occupied himself incessantly in general, and especially in political reading, though he was far from having the air of a student: but his rooms were always in confusion from the mixture of heterogeneous materials that were accumulated in them. His residence at Cambridge was perhaps the happiest time of his life; his spirits unwearied, his health unbroken, his feelings acute, and his conversation brilliant, though simple and unaffected.

In the summer of 1784 he paid a visit to Denmark, to Sweden, and to Scheele, whose acquaintance extremely delighted him, and most of all from the simplicity of the apparatus that he employed in his researches. A year or two afterwards he went to France, and being taken ill at Paris, he was joined there by his friend Harwood, with whom he returned through Holland and the Netherlands; at the time that the bigotted people of the Low Countries were in insurrection against a philosophical despot, while Holland remained free and prosperous.

He was particularly intimate with Dr Milner, the Master of Queen's College, and was recommended by his signature, together with those of Waring, Maskelyne, Jebb, and Watson, as a Fellow of the Royal Society, into which he was admitted in January 1785. He removed, together with his friend Harwood, in December 1786, from Christ's College to Emmanuel, and in 1788 he took a degree of Bachelor of Physic.

In 1791 he communicated to the Royal Society his very interesting discovery of a mode of obtaining carbon from the carbonic acid. Having observed that charcoal did not decompose the phosphate of lime, he concluded that phosphorus ought to decompose the carbonate of lime, and the result fully justified his manner of reasoning.

He paid a third visit to the Continent in 1792, intending to go on through France into Italy, and arrived at Paris not long before the 10th of August; but he saw some indications of an impending convulsion, and was fortunate enough to quit Paris on the 9th. He visited Gibbon at Lausanne, and was much interested in the sagacity that this eminent writer displayed in his conversation. He went on to Rome and Florence, where he was fully impressed with all the admiration that he had been taught to anticipate for the treasures of ancient and modern art possessed by those cities; and in his return through Germany, he was greatly amused by the mixture of knowledge and credulity that he observed among the studious of that country. At Paris he found every thing enveloped in gloom and overwhelmed with terror, in 1793; his friend Lametherie was alarmed by the visit which he paid him, but he had the integrity to preserve for him entire some property of considerable value, with which he had entrusted him.

Upon his arrival in London, Mr Tennant took chambers in the Temple, and was in the habit of living much with some of his early acquaintance, who had adopted the law as their profession; to his own he was in great measure indifferent, neither seeking to practise it, nor being well calculated to succeed greatly in it with the public, though he studied it with attention, and took pains to make himself master of its history and its philosophy, being a particular admirer of Sydenham, when considered in relation to the age in which he lived. He took his degree of Doctor of Physic in 1796, and in the same year he gave the Royal Society a paper on the quantity of carbonic acid afforded by the diamond, which he measured by heating it with nitre, and obtaining a precipitate by the addition of muriate of lime; and he found that the diamond afforded no more carbonic acid than an equal weight of charcoal. A subsequent communication contained the result of his observations on the action of heated nitre on gold and platina.

The love of travelling appeared to be his predominant passion; he studied in his travels, not only the natural and political history of the countries that he saw, but also their languages, and the philosophy of their etymologies. He observed, too, the peculiarities of their agriculture; and, in 1797, he determined, after visiting an agricultural friend in Lincolnshire, to devote his attention to practical farming as a serious pursuit. He purchased some allotments of unenclosed land in that neighbourhood, but he left the management of them chiefly to his friend, and made afterwards considerable additions to the property by further purchases. In 1798 or 1799, he bought a tract of newly enclosed land on the Mendip hills, near Chedder, where he built a house, and resided for some months every summer through the remainder of his life. These speculations, though their results were at first doubtful, yet succeeded remarkably well on the whole; more especially considering the benefit that his health derived from the travelling and the exercise that they rendered necessary: but they occupied too much of his attention, and of that time which might have been employed so much more to the advantage of the public, and to his own ultimate satisfaction.

Tennant.

In 1799 he gave the Royal Society a paper on the magnesian limestone, or dolomite, which he considers as rather a combination than an accidental mixture; and the forms of the crystals, as they have been determined by later observers, together with the laws of definite proportions, have tended to confirm this conjecture: he found that grain will scarcely germinate, and soon perishes, when sown in the neutral carbonate of magnesia. In 1802 he published his paper on emery, which he showed to be a substance similar to the corundum or adamantine spar of China, and not an ore of iron, as had been commonly supposed. In the month of July he was making some experiments on crude platina, when he discovered in it a singular dark powder, which was left undissolved by the nitromuriatic acid, and which was also observed the next year by Messrs Descotils and Vauquelin. In 1804 Mr Tennant showed that the powder contained two new metals, which he named *Iridium* and *Osmium;* and he received the Copleian medal from the Royal Society in November, as an acknowledgment of the merit of his various chemical discoveries. In 1805 and 1806 he paid two successive visits to Ireland, by way of Scotland, one of them in company with Browne the traveller, for whom he had a high esteem, and to whom he suggested the observation of the temperature of boiling water as a mode of determining the heights of mountains; a method, however, which had been long before recommended by Achard and others.

He became latterly more fond of general society than he had been in his earlier years, and he used to receive miscellaneous parties at his chambers, and to show them prints, and minerals, and novelties of various kinds. In 1812 he was persuaded to convert these mixed exhibitions into a more regular course of lectures, principally upon mineralogy, calculated especially for the ladies of his acquaintance, and which highly delighted all his audience: "Their attention was perpetually kept alive by the spirit and variety with which every topic was discussed, by anecdotes and quotations happily introduced, by the ornaments of a powerful but chastised imagination, and, above all, by a peculiar vein of pleasantry, at once original and delicate, with which he could animate and embellish the most unpromising subjects;" —a circumstance which, though not of much immediate importance to the public, yet probably led him the more readily to accept the Professorship at Cambridge, and would thus, if he had survived longer, have greatly extended the sphere of his utility.

He delivered, in 1813, a lecture on mineralogy to the Geological Society, and gave them also an account of his analysis of a volcanic substance from the Lipari Islands containing the boracic acid, which has since been examined on the spot by Dr Holland. In the month of May he was elected Professor of Chemistry in the University of Cambridge, all opposition having been withdrawn before the election. The following spring he gave his first and last course of lectures there. His introductory lecture still exists in manuscript, and is said to contain a masterly sketch of the history of the science. He communicated to the Royal Society, in 1814, a paper on the easiest mode of procuring potassium, and another on the economy of heat in distillation, proposing to heat a second boiler by the condensation of the steam of the first. In the spring and summer of this year he was occupied in searching for the origin of iodine, and he succeeded in detecting this substance in sea-water, by the test of its tarnishing the surface of leaf silver. One of the last services, that he rendered the Royal Society, was in the capacity of a member of a committee which was formed in order to investigate, at the request of the government, the degree of danger that might attend the general introduction of gas lights into the metropolis; he undertook, together with his friend Dr Wollaston, to make some experiments upon the inflammation of the gas, and they discovered conjointly the very important fact, that the gas contained in a small tube will not communicate the flame: a fact which, in the hands of Sir Humphry Davy, has been rendered productive of consequences so important to the public safety; although Sir Humphry having been abroad at the time of this investigation, and the report of the committee not having been then published, he had to rediscover this truth, and many more, in his most ingenious and successful researches.

It was early in the month of September that Mr Tennant went for the last time to France, being impatient to observe the changes that an eventful interval of twenty years had produced in that highly interesting country. He was greatly delighted with Lyons and Marseilles, and, returning to Paris in November, he lingered there till February 1815; on the 15th of that month he arrived at Calais; the 20th he went to Boulogne with Baron Bulow, in order to embark there; they did embark on the 22d, but were forced back by the wind, and meant to try again in the evening; in the meantime, they took horses and went to see Bonaparte's Pillar, about a league off, and going off the road on their return, to look at a small fort, of which the drawbridge wanted a bolt, they were both thrown, with their horses, into the ditch. Bulow was only stunned, but Tennant's skull was so severely fractured, that he died an hour after.

His papers published in the *Philosophical Transactions* were eight in number. 1. *On the Decomposition of Fixed Air*, 1791, p. 182. 2. *On the Nature of the Diamond*, 1797, p. 123. 3. *On the Action of Nitre upon Gold and Platina*, p. 219. 4. *On the different sorts of Lime used in Agriculture*, 1799, p. 305. 5. *On the Composition of Emery*, 1802, p. 398. 6. *On two Metals found in the Black Powder remaining after the Solution of Platina*, 1804, p. 411. 7. *On an easier Mode of procuring Potassium than that which is now adopted*, 1814, p. 578. 8. *On the Means of producing a double Distillation by the same Heat*, p. 587.

9. The analysis of *A Volcanic Substance containing the Boracic Acid* appeared in the *Transactions of the Geological Society*, Vol. I. 1811.

Mr Tennant was tall and slight in his person; his face was thin, and his complexion light; he resembled a little the portraits of Locke; he was general-

ly negligent in his dress, but, on the whole, agreeable in his appearance. He was distinguished for good sense, for quickness of perception, and for penetration; but, as his friend and biographer Mr Whishaw observes, in the admirably energetic sketch that he has given of his character, he was one of those who, to use the words of Dr Johnson, "without much labour, have obtained a high reputation, and are mentioned with reverence rather for the possession than the exertion of uncommon abilities." "His curiosity and activity were incessant; he had a vigilance of observation which suffered nothing to escape him, and was continually gaining new information from a variety of interesting sources. But although the knowledge thus acquired was remarkable for its correctness, and complete for the purposes of its possessor, yet the industry and perseverance, by which it ought to have been embodied and made permanent for the benefit of others, were too often altogether wanting. The ardour and energy of Mr Tennant's mind co-operated unfortunately, in this respect, with his want of method and of systematic habits of application; since he was constantly pressing on to new discoveries, instead of arranging and bringing to perfection those which he had already made. His memory was a great storehouse of discoveries, and hints for discovery, of ascertained facts, probable conjectures, and ingenious trains of reasoning relative to the various important subjects upon which he had at any time been engaged. These he was continually treasuring up, with the intention of reducing them to order, and preparing them for use at a more convenient season. But that period rarely arrived. In the carelessness of intellectual wealth, he neglected those stores of knowledge which he had accumulated, and suffered them to remain useless and unproductive, till his attention was recalled to them, perhaps after a long course of years, by some new fact or discovery, some remark in conversation, or other accidental occurrence."

The effect of his peculiar cast of humour was heightened by a perfect gravity of countenance, a quiet familiar manner, and a characteristic simplicity of language. He was firmly attached to the general principles of freedom, being fully convinced "of their influence in promoting the wealth and happiness of nations; a due regard to these principles, he considered as the only solid foundation of the most important blessings of social life, and as the peculiar cause of that distinguished superiority, which our own country so happily enjoys among the nations of Europe." "The cheerful activity of a populous town, the improvements in the steam-engine, the great galvanic experiments, and above all the novelty and extent of the prospects afforded by that revolution in chemical science which has illustrated our own age and country; these magnificent objects, when presented to Mr Tennant's mind, excited in him the liveliest emotions, and called for the most animated expressions of admiration and delight." "He thought himself passionate and irascible; and certainly his feelings were quick; but they were transitory." He possessed a strong sense of high honour, as well as of duty; and his liberality and humanity were evinced by some practical occurrences in which he had occasion to exercise them: his steward had defrauded him, and when the day of reckoning came, had destroyed himself: he not only forgave the debt, but provided also for the widow and her family.

"His amiable temper and unaffected desire of giving pleasure, no less than his superior knowledge and talents, had rendered him highly acceptable to a numerous and distinguished circle of society, by whom he was justly valued, and by whom his premature death was sincerely lamented. But the real extent of his private worth, the genuine simplicity and virtuous independence of his character, and the sincerity, warmth, and constancy of his friendship, can only be felt and estimated by those to whom he was long and intimately known, and to whom the recollection of his talents and virtues must always remain a pleasing though melancholy bond of union."

[Whishaw in] Thomson's *Annals*, Vol. VI. 1815. p. 1, 80. (A. L.)

THOMPSON (Sir Benjamin, Count RUMFORD), a well known Natural Philosopher and Political Economist, was born in 1753, at a village in New Hampshire, then called Rumford, and now Concord.

His father died while he was very young, and his mother married another man, who banished him from her house almost in his infancy: he inherited only a small pittance from an uncle, who died soon after his father. A clergyman named Bernard showed him great kindness, and taught him some of the higher mathematics at an early age, so that at fourteen he was able to calculate and delineate an eclipse of the sun. He had been intended for some commercial employment; but he preferred the pursuit of literature in any form: he attended the lectures of Dr Williams, and afterwards those of Dr Winthrop, the astronomer, at the College of "Havard;" and while he was still a stripling, he was established in the temporary occupation of a village schoolmaster; hoping, however, for an early opportunity to engage in some more agreeable employment: and at nineteen, he was fortunate enough to obtain the hand of Mrs Rolfe, daughter of Mr Walker, a clergyman, who had been employed with considerable credit in conducting some publie business. For a year or two he lived retired and happy: but having obtained a commission of Major in the Militia from the Governor of the province, together with some other distinctions, of a civil nature, he was consequently led to adhere to the party of the Royalists, and he was soon obliged, by the success of the Independent forces, to take refuge at Boston, then occupied by the English troops. It was in November 1773 hat he secretly quitted his residence, leaving his wife, whom he never saw again, and his infant daughter, who joined him twenty years after in Europe.

He was employed to raise a regiment for the King's service; but when Boston was evacuated, in 1776, he was sent with some important dispatches to England. Here he soon acquired the confidence of Lord George Germaine, then Colonial Secretary of State, and was appointed Secretary of the province

Thompson. of Georgia, though he never exercised the office: but he remained attached to that department of the public service.

In 1777 he commenced his career as an experimental philosopher, by employing his leisure hours, during a visit to Bath, in making some experiments on the cohesive strength of different substances: and upon his return to London, he communicated them to Sir Joseph Banks, with whom he formed an intimate acquaintance, which he kept up throughout the remainder of his life. In 1778 he was admitted a Fellow of the Royal Society, and he made in that year his first experiments on gunpowder. In order to pursue these experiments, he went, in 1779, on board of the Victory of 110 guns, commanded by his friend Sir Charles Hardy. He passed the whole of the campaign on board of the fleet; and the results of the observations, that he then made, furnished the materials of a chapter which he contributed to Stalkart's Treatise on Naval Architecture. He added to it a code of signals for the Navy, which was not published. In 1780 he was appointed Under Secretary of State, and he was constantly employed, for some little time, in the office on the business of the war. He succeeded, by means of his American friends and agents, in raising a regiment of cavalry, called the King's American Dragoons, of which he was appointed Lieutenant-Colonel Commandant; and this success induced him to go to America to serve with it. At Charlestown he was entrusted with the command of the remains of the cavalry of the British army;—he speedily restored the discipline of the corps, and gained its confidence and attachment: he often led it on against the enemy, and frequently with considerable success. He proceeded, in 1782, to New York, where he assumed the command of his own regiment, having received the colours from the hand of Prince William Henry, now Duke of Clarence. In the autumn, General Clinton was succeeded by Sir Guy Carlton, whose friendship and confidence he speedily obtained: his regiment was recruited from the fragments of several others, and he was sent for the winter to Huntingdon in Long Island. He was chosen, in 1783, to conduct the defence of Jamaica, which was then threatened by the enemy: but the general peace superseded the necessity of the intended expedition.

After his return to England, he made great efforts in the cause of the loyalist officers, and he was successful in persuading the Ministry to make a proper provision for them: he was himself made a full Colonel, upon the recommendation of General Carlton, only two years after his appointment as Lieutenant-Colonel. He had acquired a strong predilection for a military life, and was desirous of being sent with his regiment to the East Indies: and when the regiment was reduced, he wished to serve with the Austrians in a war which was then meditated against the Turks.

With this view he left England in September 1783, and on his passage to Boulogne, he had an agreeable ship-mate in the person of Gibbon, the historian, who did justice to his merits as a "soldier, philosopher, and statesman." At Strasburg, his appearance

on the parade in his uniform excited the attention of the present King of Bavaria, then Prince Maximilian of Deux Ponts, who invited him to his table, and being delighted with the accuracy and extent of his military knowledge, gave him a strong recommendation to his uncle, then Elector: and instead of a day or two, as he had intended, he staid a fortnight at Munich. He was also very cordially received at Vienna, and passed a part of the winter there; but the war against the Turks not taking place, he went by Venice and the Tyrol again to Munich, where he arrived in the winter of 1784; and being formally invited by the Elector to enter his service, he went to London to ask leave to accept the proposal; and it was granted him, together with the honour of Knighthood. On his return to Bavaria, he was made a Colonel of cavalry, and Aide-de-Camp-General to the Elector. The first four years of his residence at Munich were principally employed in acquiring information, and in preparing his plans of reform: and in the mean time he continued his physical researches. He made his first experiments on heat in 1786, during a journey to Manheim. In 1785 he was made Chamberlain to the Elector, and member of the Academies of Munich and of Manheim: in 1786 he received from the King of Poland the Order of St Stanislaus: in 1787 he took a journey to Berlin, and was made a member of the Academy of Sciences of that city: in 1788 he was appointed Major-General of the Bavarian cavalry, and Privy Counsellor of State; and he was placed at the head of the War Department, in order to pursue his plans for the improvement of the army.

It was in 1789 that he established the House of Industry at Manheim: he founded also the Military Academy of Munich; he improved the military Police of the country; he formed Schools of Industry for the wives and children of the soldiers; and he embellished the city by a new arrangement of the public gardens. The House of Industry at Munich, which he has described at large in his *Essays*, was founded in 1790: and from this period may be dated the total abolition of mendicity in Bavaria. His exertions were rewarded by the rank of Lieutenant-General of the Bavarian armies, and by a regiment of artillery. In 1791 he was created a Count of the Holy Roman Empire, and obtained the Order of the White Eagle.

His health having suffered from constant application, he obtained permission to take a journey into Switzerland and Italy, and he returned to Bavaria in 1794. He had a severe illness at Naples, and he was not sufficiently recovered, upon his return, to resume his active duties; but he employed himself in writing the first five of his *Essays*. In 1795, he came to England in order to publish the *Essays*, and in hopes of exciting the public attention to the importance of attempting a similar reform among the lowest orders in Great Britain. He went to Dublin in 1796, to pay a visit to Lord Pelham, now Earl of Chichester, then Secretary of State for Ireland; and he was of essential service in the arrangement of several of the public institutions of that country. He

Thompson. was made a Member of the Royal Irish Academy, and of the Society for the Encouragement of Arts; and he received, after having left the country, the public thanks of the Grand Jury of the county of Dublin, and of the Lord Mayor of that city, as well as of the Lord Lieutenant at the head of the Government. Upon his return to London, he superintended some improvements at the Foundling Hospital, and presented several models of machines and implements to the Board of Agriculture: and he established two prizes, for discoveries relating to Heat and Light, by placing two sums of L. 1000 in the British and in the American funds, to be adjudged biennially, for Europe by the Royal Society of London, and for America by the American Academy of Sciences.

He was recalled to Bavaria by the exigencies of the moment, which were such as to cause the Elector to take refuge in Saxony; General Moreau having advanced with his army to the confines of Bavaria. After the battle of Friedberg, Count Rumford was left in command of the Bavarian army, with instructions to act according to his discretion under the circumstances that might occur; and his firmness was such, as to prevent either the Austrians or the French from entering Munich. On the Elector's return, he was placed at the head of the department of the general police of Bavaria. His exertions in this office were such, as to impair the state of his health, and by way of an honourable retirement, he was sent to England in the capacity of Envoy Extraordinary and Minister Plenipotentiary: but being a subject of the King of England, he was judged incapable of being received as the diplomatic agent of a foreign court, and he, therefore, continued to live in England as a private individual.

He was very active about this time in projecting and superintending the establishment of the Royal Institution of Great Britain, which was more particularly intended for the application of science to the conveniences and comforts of civil and domestic life, but which has been no less successful in giving opportunity and facility to some of the most refined researches in chemistry and natural philosophy that have distinguished the age, than in serving as a medium for making the treasures of science accessible to the less studious part of the public, and as a model for a variety of other similar undertakings in different parts of the world.

Count Rumford was soon afterwards officially invited to America by the government of the United States, with an offer of an honourable establishment in a public situation; but he considered it as inconsistent with his engagements in Europe to accept the proposal. In the autumn of 1800, when he went to Scotland, a visit of ceremony was paid him by the magistrates of Edinburgh: he was consulted respecting the abolition of mendicity, and the measures that he recommended were speedily executed with complete success. He was made an honorary member of the Royal Society, and of the Royal College of Physicians of Edinburgh; and he received a gold snuff box as a compliment for his assistance in reforming the culinary establishment of Heriot's Hospital.

After so active and diversified a career, it was not Thompson. to be expected that he would be satisfied with the monotony of a permanent residence in London: he was so accustomed to labour for the attainment of some object, that when the object itself was completely within his reach, and the labour was ended, the prospect, which ought to have been uniformly bright, became spontaneously clouded, or even the serenity became unenjoyable for want of some clouds to afford a contrast. He had fitted up a small house at Brompton, with every contrivance for comfort and convenience that could render it fit for the abode of hospitality and of luxury; and the arrangements are fully described in the *Bibliothèque Britannique* of his friend, Professor Pictet; but after all he never was known to give a single entertainment in it. The enthusiasm excited by the novelty of some of his inventions had subsided, and he was even mortified by becoming, in common with the most elevated personages of the country, the object of the impertinent attacks of a popular satirist. It was partly, however, if not entirely, the superiority of the climate of France, that determined him to remove to Paris in the spring of 1802: he went in the summer to Munich, and the following year he made a tour in Switzerland and in Bavaria, accompanied by Me. Lavoisier, whom he married soon after their return: but their habits were incompatible with matrimonial comfort, and they separated soon after; Count Rumford retiring to Auteuil, about four miles from Paris, where he occupied a house which had formerly belonged to Helvetius and to Cabanis, while his lady continued to live in the metropolis. His latter years were passed almost wholly in solitude; he saw only his neighbour Mr Caneleux, Mr Underwood, and a Mr Parker, an American: he did not even attend the sittings of the Institute, though he had been made one of its eight foreign associates some time before, and always retained a high esteem for its secretary Cuvier, and for some others of its members. His income was abundantly sufficient for his own expenses, having obtained from the gratitude of the King of Bavaria a pension of L. 1200 a year; and he was allowed by Bonaparte to remain unmolested, though a British subject, when it was found that he had no intercourse with society, amusing himself principally in walking about his garden, and in a solitary game of billiards. He had so completely persuaded himself, in the latter part of his life, of the great superiority of broad wheels above narrow ones, that he drove about the streets of Paris in a broad wheeled chariot; and having rediscovered, after Professor Leslie, that black bodies radiate more heat than others, he wore, in the winter, a white hat and a white coat, in order to economize the heat of his person. "These peculiarities, and a peremptory unyielding disposition," says one of his biographers, "were the causes that set him apart from social intercourse, and in all his connexions in life, seem to have rendered him less the object of personal attachment than of esteem for his talents and activity." He was about to return to England when he died, the 21st August 1814, leaving only one daughter, who still resides in his house at Brompton.

1. Count Rumford's first publication appears to have

Thompson. been the chapter on *Marine Artillery* that he furnished to Stalkart's *Treatise on Naval Architecture*, 1780.

2. *New Experiments on Gunpowder, with the Description of an Eprouvette. Phil. Trans.* 1781. P. 230. The effect of the powder on the ball was measured by the recoil of the piece, with a correction deduced from the recoil when the piece was empty. It was observed to be sooner heated when fired without ball than with it. The force of the powder is made at least 1300 atmospheres, upon Robins's principles.

3. *New Experiments upon Heat. Phil. Trans.* 1786. P. 273. These experiments relate principally to the conducting powers of various mediums for heat; but the results are unavoidably complicated with the effects of radiation, in consequence of which a vacuum is supposed to possess a conducting power more than half as great as that of common air.

4. *Experiments on the Production of Dephlogisticated Air from Water with various Substances. Phil. Trans.* 1787. P. 84. These experiments tend to show that the air obtained, by Priestley and Ingenhousz, from plants under water, was derived rather from the water itself than from the substances immersed in it.

5. *Experiments made to determine the Positive and Relative Quantities of Moisture absorbed from the Atmosphere by Various Substances.* P. 240. He finds that wool is more absorbent of moisture than any other substance compared with it; and hence explains the supposed advantage of woollen worn next the skin.

6. *Experiments on Heat. Phil. Trans.* 1792. P. 48. The author attributes the effect of loose substances in obstructing the passage of heat to their attraction for air, and to their impeding its circulation; and he supposes this to be the only manner in which elastic fluids communicate heat.

7. *Account of a Method of Measuring the Comparative Intensity of Light emitted by Luminous Bodies. Phil. Trans.* 1794. P. 67. Placing them at such distances, that the shadows cast by each may appear equally dark.

8. *Letter announcing a Donation for a Prize Medal. Phil. Trans.* 1797. P. 215.

9. *Experiments to determine the Force of Fired Gunpowder.* P. 272. This force he supposes to amount to between 20,000 and 50,000 atmospheres, instead of 10,000, as Bernoulli computed it; but he makes a great mistake in supposing that the whole of the water which can possibly be contained in the gunpowder would be sufficient to furnish as much steam as would be required, since steam, under a pressure of 20,000 atmospheres, must be considerably more dense than water itself. (See Steam Engine, in this *Supplement*.)

10. *Inquiry concerning the Source of the Heat excited by Friction. Phil. Trans.* 1798. P. 80. The capacity of the chips of iron afforded by friction in boring a cannon, was found not to differ from that of the iron in its original state: hence it is inferred that the heat could not have been furnished by them, and that it must probably have been generated. Mr Haldalt afterwards repeated the experiment under circumstances still more decisive; and Sir Humphry Davy showed that two pieces of ice rubbed together, in a room below the freezing temperature, would melt each other. Thompson.

11. *Inquiry concerning the Chemical Properties that have been attributed to Light.* P. 449. He attributes these properties to the effect of an intense heat confined to a small space; but the later experiments on the chemical effects of the spectrum are sufficient to supersede this opinion.

13. *An Account of a Curious Phenomenon observed on the Glaciers of Chamouny, with some Observations on the Propagation of Heat in Fluids. Phil. Trans.* 1804. P. 23. An effect depending on the expansion of water in cooling near the freezing point.

14. *Concerning the Nature of Heat, and the Mode of its Communication.* P. 77. He conjectures that cold is a positive quality, capable of being propagated by radiation.

Several of these memoirs were reprinted under the title of *Philosophical Papers.* Vol. I. 8. Lond. 1802.

15. The *Essays* constitute 4 volumes 8vo. Lond. 1795 . . 1800. Reprinted 1800. In French, 2 v. 8. Genev. 1799. *Receuil de Rapports* . . sur les soupes. Par. 1801. They are 18 in number.

i. Account of an Establishment for the Poor at Munich. In Ital. 8. Venice, 1798.

ii. On Establishments for the Poor in general.

iii. Of Food, and of Feeding the Poor.

iv. Of Chimney Fireplaces.

v. Account of several Public Institutions formed in Bavaria.

vi. On the Management of Fire, and the Economy of Fuel.

vii. On the Propagation of Heat in Fluids, extending to Liquids the doctrine which he had before advanced respecting Elastic Fluids.

viii. On the Propagation of Heat in Various Substances. *Phil. Trans.*

ix. Experimental Inquiry concerning the Source of Heat excited by Friction.

x. On Kitchen Fireplaces and Kitchen Utensils.

xi. On Chimney Fireplaces.

xii. On the Salubrity of Warm Rooms in Cold Weather.

xiii. On the Salubrity of Bathing, and the Construction of Warm Baths.

xiv. Supplementary Observations on the Management of Fires.

xv. On the Use of Steam for Transporting Heat.

xvi. On the Management of Light in Illumination, with an Account of a New Portable Lamp.

xvii. On the Source of the Light manifested in the Combustion of Inflammable Bodies.

xviii. On the Excellent Qualities of Coffee, and the Art of Making it in Perfection.

16. There are several little papers on *Steam Kitchens*, on the *Strength of Soft Materials*, and on some other similar subjects, in the first numbers of the *Journals* of the Royal Institution. 8. Lond. 1800.

17. The series of investigations relating to Heat and Light, which Count Rumford began to communicate to the Royal Society, were continued, and rather more fully detailed, in several of the volumes of the *Memoirs of the Institute*, Mathematical Class; into which they were, of course, admitted as the productions of a Foreign Associate. The first of these is in the sixth volume. 4. Par. 1806. P. 71, containing a *Description of a New Instrument;* a thermoscope, or a differential thermometer, resembling that of Leslie. (18.) The second, P. 74. *Researches on Heat;* showing the effect of the difference of surface on radiation. (19.) iii. P. 88. *Further Experiments*, in the effect of blackening the surface. (20.) iv. P. 97. *Researches Continued;* on the different properties of bodies with respect to radiation, and to conducting power. (21.) v. P. 106. *Further Researches;* some good experiments on the passage of heat through solids. (22.) vi. P. 123. *Experiments on the Heat of the Solar Rays;* which was found not to be affected by their convergence or divergence, or by their having met in a focus and crossed each other. (23.) vii. Vol. VII. i. 1806. P. 78. *Remarks on the Temperature of Water at the Maximum of Density;* making it 41° of Fahrenheit, or 5° centigrade. *Phil. Trans.* 1804. (24.) viii. Vol. VIII. i. 1807. P. 223. *On the Dispersion of the Light of Lamps by Screens of Ground Glass, Silk, and so forth, with a Description of a New Lamp.* (25.) ix. P. 249. *On the Cooling of Liquids in Vases of Porcelain, gilt and not gilt;* showing the utility of gilding them externally, with some good reasoning on the nature of heat.

26. He was latterly engaged in composing a work on *The Nature and Effects of Order*, which he never completed, although no person was better qualified to write on the subject.

Count Rumford certainly possessed considerable facility of invention, and there was a very laudable spirit of originality in his views and modes of reasoning, although he had never leisure to acquire profound learning in any department of study. "In person he was above the middle size, with a dignified and pleasing expression of countenance, and a mildness in his manner and his tone of voice. He was ambitious of fame and distinction, and had too great a propensity to dictate," without sufficiently regarding the opinions of others who were of equal authority with himself. His mode of life was abstemious, and his health was even supposed to have suffered from too great abstinence, though his regimen was much more the result of medical opinions respecting his health, than of his own peculiar taste for temperance.

[Pictet, *Bibliothèque Britannique*, and Baldwin's *Literary Journal*. *Gent. Mag.* Vol. LXXXIV. Aikin's *General Biography*, X. 4. Lond. 1805. Chalmers' *Biographical Dictionary*, XXIX. 8. Lond. 1816.] (A. L.)

TIDES.

The investigation of the phenomena of the tides has been justly considered as uniting some of the greatest difficulties that occur in the various departments of natural philosophy and astronomy. It implies, first, a knowledge of the laws of gravitation, concerned in the determination of the forces immediately acting on the sea, and of the periods and distances of the celestial bodies, which modify the magnitudes and combinations of these forces; and secondly, of the hydraulic theories of the resistances of fluids, and of the motions of waves and undulations of all kinds, and of the theoretical determination of the form and density of the earth, as well as of the geographical observation of the breadth and depth of the seas and lakes, which occupy a part of its surface; so that the whole subject affords abundant scope for the exercise of mathematical skill, and still more for the employment of that invention and contrivance, which enables its possessor to supersede the necessity of prolix computations, wherever they can be avoided.

The history of the theory of the tides is naturally divided into several periods in which its different departments have been progressively cultivated. The ancients, from the times of Posidonius and Pytheas, and the moderns before Newton, were contented with observing the general dependence of the tides on the moon, as following her transit at an interval of about two hours, and their alternate increase and decrease not only every fortnight, but also in the lunar period of about eight years; the second step consisted in the determination of the magnitude and direction of the solar and lunar forces, by which the general effects of the tides were shown, in the *Principia*, to be the necessary consequences of these forces: the third great point was the demonstration of Maclaurin, that the form of an elliptic spheroid affords an equilibrium under the action of the disturbing forces concerned; while the further contemporary illustrations of the subject by Euler and Bernoulli, though they afforded some useful details, involved no new principle that can be put in competition with Maclaurin's demonstration: the fourth important step was made by Laplace, who separated the consideration of the *form*, affording mere equilibrium, from that of the *motion* occasioned by the continual change of that form, while former theorists had taken it for granted, that the surface of the sea very speedily assumed the figure of a fluid actuated by similar forces, but remaining perfectly at rest, or assuming instantly the form in question. Laplace's computation is however limited to the case of an imaginary ocean, of a certain variable depth,

assumed for the convenience of calculation, rather than for any other reason. Dr Thomas Young has extended Laplace's mode of considering the phenomena to the more general case of an ocean covering a part only of the earth's surface, and more or less irregular in its form; he has also attempted to comprehend in his calculations the precise effects of hydraulic friction on the times and magnitudes of the tides. As far as the resistance may be supposed to vary in the simple ratio of the velocity, Dr Young's theory is sufficiently complete, and explains several of the peculiarities which are otherwise paradoxical in their appearance; but there still remains a difficulty to be combated with respect to the effects of a resistance proportional to the square of the velocity, and this, it is hoped, will be in great measure removed in the present article, which, however, from the space that is allotted to it, must be considered rather as a supplementary fragment than as a complete treatise. It will be divided into four sections: The first relating to the contemporaneous progress of the tides through the different seas and oceans, as collected from observation only: the second to the magnitude of the disturbing forces tending to change the form of the surface of the earth and sea: the third to the theory of compound vibrations with resistance; and the fourth to the application of this theory to the progress and successive magnitudes of the tides, as observable at any one port.

Sect. I.—*Of the Progress of Contemporary Tides, as inferred from the times of High Water in Different Ports.*

The least theoretical consideration, relating to the tides, is that of their progress through the different parts of the ocean, and of its dependent seas. The analysis of these ought to be very completely attainable from direct observation, if the time of high water had been accurately observed at a sufficient number of ports throughout the world; and, on the other hand, if the earth were covered in all parts with a fluid of great and nearly uniform depth, the tides of this fluid would be so regular, that a very few observations would be sufficient to enable us to deduce the whole of the phenomena from theory, and to trace the great waves, which would follow the sun and moon round the globe, so as to make its circuit in a day, without any material deviation from uniformity of motion and succession. Having collected, for the actual state of the sea and continents, an abundant store of accurate observations of the precise time of high water with regard to the sun and moon, for every part of the surface, and having arranged them in a table according to the order of their occurrence, as expressed in the time of any one meridian, we might then suppose lines to be drawn on a terrestrial globe, through all the places of observation, in the same order; and these lines would indicate, supposing the places to be sufficiently numerous, so as to furnish a series of tides very nearly contemporary, the directions of the great waves, to which that of the progress of the tides in succession must be perpendicular. If, however, we actually make such an attempt, we shall soon find how utterly inadequate the observations that have been recorded are, for the purpose of tracing the forms of the lines of contemporary high water with accuracy or with certainty, although they are abundantly sufficient to show the impossibility of deducing the time of high water at any given place from the Newtonian hypothesis, or even from that of Laplace, without some direct observation. It might at least be supposed very easy to enumerate the existing observations, scanty as they may be, in a correct order; but there are a number of instances in which it is wholly uncertain whether the time observed at a given port relates to the tide of the same morning in the open ocean, or to that of the preceding evening; this inconvenience may, however, in some measure be remedied, by inserting such places in two different parts of the table, at the distance of $12\frac{1}{2}$ hours from each other. The following Table is the result of the best approximation that could be obtained in this manner, the principal hour lines having been partially traced on a map of the world, in order to afford some little direction to the correct insertion of the times of high water without the material error of half a day. The three great natural divisions of the Atlantic, the Pacific, and the Indian Oceans, are distinguished into different columns, and some of the places, which seem to form separate systems of tides, are still further subdivided in a similar manner; but this arrangement may easily be neglected by those who are inclined to question its propriety. The principal authorities are the *Requisite Tables;* Lalande's *Treatise*, in the fourth volume of his *Astronomy;* a manuscript *Hydrographical Memoir* by Mr Henry Foster, Lieut. R. N. of his Majesty's ship Conway, Capt. Basil Hall; and *A Series of Observations made at the Island of Ascension in* 1820, by Captain Campbell, R. N., obligingly communicated by Captain Hall to the author of this Article.

Table of the Time of High Water at the Full and Change of the Moon; reduced to the Meridian of Greenwich.

Atlantic.	Pacific.	Indian.	Longitude.	H. W. Gr. T.
			H. M.	H. M.
S. Georgia			1.26 W.	1. 0
Cape of Good Hope			1.14 E.	1.30
St Helena			0.23 W.	2.38
Goree Island. (See below)				
Cape Corse			0. 7	3.35
Canaries. (See below)				
Rio Janeiro			2.53	4.58
I. Martin Vaz			1.56	5.41
I. Ascension			0.57	5.42 C.
Christmas Sound			4.46	7.10
St Jago			1.34	7.34 or 12.34 Lal.
Pt. Désiré			4.20	8.35
	St Helena, S. A.		4.40	8.40
	Quibo		5.29	8.59
Sierra Leone			0.53	9. 8
	Easter I.		7.19	9.19
St Julian's			4.35	9.20

Atlantic. Pacific. Indian.	Longitude.	H. W. Gr. T.
Maragnon, Mouth	3.20	9.20
St John's, Newf.	3.30	9.20
Guadaloupe	4. 7	10. 7
Panama	5.21	10.21 Lal.
Tortugas	4.51	10.51
Cape Blanco	8.16	10.54
Bermudas	4.14	11.14
Martinique	4. 5	11.35
Guayaquil	5.17	11.17
Senegal	1. 6	11.36
Callao	5. 8	11.38
Halifax	4.14	11.44
Marquesas	9.16 to 9.17	11.46 to 12.16
Quebec	4.44	12.14
Cape La Hogue	0. 8	12.38
Panama	5.21	12.41 F.
Gibraltar	0.20	12.50
Tahoga, Pan. Bay	5.22	13.10 F.
Funchal	1. 8	13.42
Portobello	5.19	13.19
[S. Georgia	2.26	13.26 ?]
Cape Bojador	0.58	13.28
Funchal	1. 8	13.42
Churchill R. P. of Wales's Fort	6.17	13.37
Tercera	1.49	13.34 or 14. 4
New York	4.57	13.57
Cape Henlopen, Virg.	5. 1	14. 1
Cadiz	0.25	14. 5 uncertain
Karakakooa B.	10.24	14. 9
Virgin Cape, Pat.	4.32	14.32
Valparaiso	4.49	14.50
Cape Charles	4.57	14.57
Goree Island	1.10	15.10
York Fort	6. 9	15.19
Lisbon	0.37	15.22
Nantes, Rhé	0. 6	15.36
Tanna	11.19	15.41
Brest	0.18	16. 3
Bayonne	0. 6	16. 6
C. St Vincent	0.36	16. 6
Corunna	0.37	16. 7
Bellisle	0.12W.	16.12 Lal.
Palmiras Pt	18.12	16.12
Port Cornwallis, And.	17.49	16.19
Rochelle	0. 5	16.20
Vannes	0.11	16.24
St Paul de Leon Morlaix	0.16	16.38 or 18. 0
Rochfort	0. 4	16.49
Bear Island	5.20	17.20
Christmas Island	19.24	17.24
Chiloe	5. 0	17.30
Cape Clear	0.38	17.38
Annamocka	11.39	17.39
St Peter and Paul Awatsha	13.25	18. 1
Kinsale	0.34	18. 4

Atlantic. Pacific. Indian.	Longitude.	H. W. Gr. T.
	H. M.	H. M.
Eddistone	0.18	18.18
Falmouth	0.20	18.20
Rotterdam I.	12.21	18.21
Drake's Island, Plymouth	0.17	18.32
Plymouth	0.17	18.47
Avranches	0. 5	18.35
Eaoowe	11.38	18.38
St Maloes	0. 8	18.38 (50ft)
Londonderry	0.29	18.59
Tonga taboo	12.20	19.10
Granville.	0. 6	19.21
Pudyona	13. 1	19.31
St Francisco	8. 8	19.33
Cork	0.34	19.34
Bristol	0.10	7.10
Barfleur	0. 5	20. 5
Cherbourg	0. 6	20. 6
Venus Pt. Otah	9.58	20.36
Mauritius	20.10	20.40
Lizard	0.21	20.45
Nootka Sound	8.27	20.47
Guernsey	0. 9	20.54
Pulo Condore	18.53	21. 9
Calcutta	18. 6	21.11
Seychelles Alm.	20.18	21.12
Stromness	0.14	21.14
New Zealand, Q. C. S.	12.13	21.23
New Zealand, Dusky B.	12.55	23.54
Honfleur	0. 1 E.	21.29
Havre	0. 0	21.30
Socotora and C. Guardafui	20.30W.	21.30
Caen	0. 1	21.31
Ulietea	10. 6	21.39 to 21.42
Huaheine	10. 4	21.55
Shoreham	0. 1	22. 1
Foul Pt. Mad.	20.41	22. 1
Botany Bay	13.55	21.55 or 23.55
St Valery en Caux	0. 3 E.	22.12
Macao	16.26W.	22.16
St Valery sur Somme	0. 6 E.	22.24
Dunnose	0. 5W.	22.20
Brighton	0. 1	22.31
Dublin	0.25W.	22.35 ?
Abbeville	0. 7 E.	22.57
Beachy Head	0. 1 E.	22.59
Cowes	0. 6W.	23. 5
Needles	0. 6W.	23. 6
Anholt	0.47 E.	23.13
Boulogne	0. 6	23.24
Hastings	0. 3	23.27
Deal Castle	0. 6	23.39
Dover	0. 5	23.40
Dengeness	0. 4	23.41
Dieppe	0. 4	23.41
Almirantes, Eagle I.	21.28W.	23.48
Almirantes, Curreuse	21.17	25.27
Portsmouth	0. 4W.	23.49

Atlantic. Pacific. Indian.	Longitude.	H. W. Gr. T.
	H. M.	H. M.
Ostend	0.12 E.	24. 3
Nieuport	0.11	24. 4
Gravelines	0. 8 E.	24.22
Aberdeen	0. 9W.	24.54
Alderney	0. 9	25. 0?
Bergen	0.21 E.	25. 9
False Bay	22.45W.	25.16
Drontheim	0.41 E.	25.34
Rouen	0. 4W.	25.41
Aberdeen	0. 9	25.54
North Cape	1.43 E.	26. 1
Leith and Edinburgh	0.13W.	26.33
Amsterdam	0.19 E.	27.11
Rotterdam	0.18	27.12
London Bridge	0. 0	27.15
Archangel	2.36 E.	27.24
Bordeaux	0. 2W.	27.32
Hamburg	0.40 E.	29.20
Bremen	0.35 E.	29.25
Antwerp	0.18 E.	30.12
Scolt Head	0. 3	30.17
Lynn	0. 2	30.43
Hague	0.17	31.58
Leostoffe	0. 7	34.23
London Bridge	0. 0	(39.45)

It may be immediately inferred from this table, first, That the line of contemporary tides is seldom in the exact direction of the meridian, as it is supposed to be universally in the theory of Newton and of Laplace; except, perhaps, the line for the 21st hour in the Indian Ocean, which appears to extend from Socotora to the Almirantes and the Isle of Bourbon, lying nearly in the same longitude. Secondly, That the southern extremity of the line advances as it passes the Cape of Good Hope, so that it turns up towards the Atlantic, which it enters obliquely, so as to arrive, nearly at the same moment, at the Island of Ascension, and at the Island of Martin Vaz, or of the Trinity. Thirdly, After several irregularities about the Cape Verd Islands, and in the West Indies, the line appears to run nearly east and west from St Domingo to Cape Blanco, the tides proceeding due northwards; and then, turning still more to the right, the line seems to run N. W. and S. E., till at last the tide runs almost due east up the British Channel, and round the north of Scotland into the Northern Ocean, sending off a branch down the North Sea to meet the succeeding tide at the mouth of the Thames. Fourthly, Towards Cape Horn again there is a good deal of irregularity; the hour lines are much compressed between South Georgia and Terra del Fuego, perhaps on account of the shallower water about the Falkland Islands and South Shetland.

In the fifth place, At the entrance of the Pacific Ocean, the tides seem to advance very rapidly to New Zealand and Easter Island; but here it appears to be uncertain whether the line of contemporary tide should be drawn nearly N. and S. from the Gallapagos to Terra del Fuego, or N. E. and S. W. from Easter Island to New Zealand; or whether both these partial directions are correct: but on each side of this line there are great irregularities, and many more observations are wanting before the progress of the tide can be traced with any tolerable accuracy, among the multitudinous islands of the Pacific Ocean, where it might have been hoped that the phenomena would have been observed in their greatest simplicity, and in their most genuine form.

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Lastly, Of the Indian Ocean the northern parts exhibit great irregularities, and among the rest they afford the singular phenomenon observed by Halley in the Port of Tonkin, and explained by Newton in the *Principia:* the southern parts are only remarkable for having the hour lines of contemporary tides considerably crowded between New Holland and the Cape of Good Hope, as if the seas of these parts were shallower than elsewhere.

These inferences respecting the progress of the tides are not advanced as the result of any particular theory, nor even as the only ones that might possibly be deduced from the table: thus the supposition that the direction in which the tides advance must be perpendicular to the hour lines of contemporary tides, is not by any means absolutely without exception, since a quadrangular lake, with steep shores in the direction of the meridian, would have the times of high water the same for every point of its eastern or western halves respectively, and there could be no correctly defined direction of the hour lines in such a case. But if any portion of the sea could be considered as constituting such a lake, its properties would be detected by a sufficient number of observations of high water, and the existing table does not appear to indicate any such cases that require to be otherwise distinguished than as partial irregularities. There may also be some doubt respecting the propriety of the addition of $12\frac{1}{2}$ hours that has been made to the time of high water in the north eastern parts of the Atlantic: but it seems extremely improbable that the same tide should travel north easterly into the English Channel and into the Northern Ocean, and at the same time westerly across the Atlantic, as it must be supposed to do, if it were considered as primarily originating in the neighbourhood of the Bay of Biscay; on the other hand, the bending of the great wave round the continents of Africa and Europe seems to be very like the sort of refraction which takes place on every shelving coast with respect to the common waves, which, whatever may have been their primitive origin, acquire always, as they spread, a direction more and more nearly parallel to that of the coast which they are approaching: and the suppositions which have been here advanced respecting the succession of the tides in different ports, allowing for the effect of a multitude of irregularities proceeding from partial causes, appear to be by far the most probable that can be immediately inferred from the table, at least in its present state of imperfection.

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Sect. II.—*Of the Disturbing Forces that occasion the Tides.*

Since the phenomena of the tides, with regard to their progress through the different oceans and seas, as they exist in the actual state of the earth's surface, appear to be too complicated to allow us to hope to reduce them to computation by means of any general theory, we must, in the next place, confine our attention to the order in which the successive changes occur in any single port, and having determined the exact magnitude of the forces, that tend to change the form of the surface of the ocean at different periods, and having also examined the nature of the vibratory motions, of which the sea, or any given portion of it, would be susceptible, in the simplest cases, after the cessation of the disturbing forces; we must afterwards endeavour to combine these causes, so as to adapt the result to the successive phenomena, which are observed at different times in any one port.

Theorem A. ("E."—Nich. *Journ.* Jul. 1813.) The disturbing force of a distant attractive body, urging a particle of a fluid in the direction of the surface of a sphere, varies as the sine of twice the altitude of the body.

The mean attraction, exerted by the sun and moon on all the separate particles composing the earth, is exactly compensated by the centrifugal force derived from the earth's annual revolution round the sun, and from its monthly revolution round the common centre of gravity of the earth and moon: but the difference of the attractions, exerted at different points of the earth, must necessarily produce a disturbing force, depending on the angular position of the point with regard to the sun or moon, since the centrifugal force is the same for them all; the disturbing force being constantly variable for any one point, and depending partly on the difference of the distance of the point from the mean distance, and partly on the difference of the direction of the luminary, from its direction with respect to the centre, or, in other words, on its parallax.

It will be most convenient for computation to consider both these forces, for a sphere covered with a fluid, as referred to the direction of the circumference of the sphere, which will differ but little from that of the fluid; and it will appear that both of them, when reduced to this direction, will vary as the product of the sine and cosine of the distance from the diameter pointing to the luminary, that is as half the sine of twice the altitude: for the difference of gravitation, which depends on the difference of the distance, will always vary as the sine of the distance from the bisecting plane perpendicular to that diameter, and will be reduced to the direction of the surface, by diminishing it in the ratio of the cosine to the radius: and the effect of the difference of direction will be originally proportional to the sine of the distance from the diameter, and will in like manner be expressed, when reduced, by the product of the sine and cosine; and each force, thus reduced, will be equal, where it is greatest, to half of its primitive magnitude, since sin cos $45° = \frac{1}{2}$. "Thus, the gravitation towards the moon at the earth's surface, is to the gravitation towards the earth as 1 to 70 times the square of $60\frac{1}{2}$, or to 256 217: and the former disturbing force is to the whole of this as 2 to $60\frac{1}{2}$ at the point nearest the moon, and the second as 1 to $60\frac{1}{2}$ at the equatorial plane, and the sum of both, reduced to the direction of the circumference, where greatest, as 3 to 121; that is, to the whole force of the earth's gravitation, as 1 to 10 334 000; and in a similar manner we find, that the whole disturbing force of the sun is to the weight of the particles as 1 to 25 736 000." Or, if we call the moon's horizontal parallax p, and substitute $\frac{1}{p}$ for the distance, the whole of the lunar disturbing force in the direction of the surface will be $\frac{3}{2} \cdot \frac{p^3}{70} = \frac{3}{140} p^3$; or, if z be the moon's zenith distance from any point of the surface, $f = \frac{3}{70} p^3$ sin cos z.

Theorem B. [F]. The inclination of the surface of an oblong spheroid, slightly elliptical, to that of the inscribed sphere, varies as the sine of twice the distance from the circle of contact; and a particle resting on any part of it, without friction, may be held in equilibrium by the attraction of a distant body, [situated in the direction of the axis.]

If a sphere be inscribed in an oblong spheroid, the elevation of the spheroid above the sphere must obviously be proportional, when measured in a direction parallel to the axis of the spheroid, to the ordinate of the sphere, that is, to the sine of the distance from its equator, and when reduced to a direction perpendicular to the surface of the sphere, it must be proportional to the square of that sine; and the tangent of the inclination to the surface of the sphere, which is equal to the fluxion of the elevation divided by that of the circumference, must be expressed by twice the continual product of the sine, the cosine, and the ellipticity, or rather the greater elevation, e, the radius being considered as unity: so that the elevation e will also express the tangent of the inclination where it is greatest, since 2 sin cos $45° = 1$; and the inclination will be every where as the product of the sine and cosine.

If, therefore, the density of the elevated parts be considered as evanescent, and their attraction be neglected, there will be an equilibrium, when the ellipticity is to the radius as the disturbing force to the whole force of gravitation: for each particle, situated on the surface, will be actuated by a disturbing force tending towards the pole of the spheroid, precisely equal and contrary to that portion of the force of gravitation which urges it in the opposite direction down the inclined surface. Hence, if the density of the sea were supposed inconsiderable, in comparison with that of the earth, the radius being 20 839 000 feet, the greatest height of a lunar tide in equilibrium would be 2.0166 feet, and that of a solar tide .8097: that is, supposing the moon's horizontal parallax about 57′, and her mass $\frac{1}{70}$ of that of the earth.

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Theorem C. [G]. The disturbing attraction of the thin shell, contained between a spheroidical surface and its inscribed sphere, varies in the same proportion as the inclination of the surface, and is to the relative force of gravity depending on that inclination, as three times the density of the shell, to five times that of the sphere.

We may imagine the surface of the sphere to be divided by an infinite number of parallel and equidistant circles, beginning from any point at which a gravitating particle is situated, and we may suppose all these circles to be divided by a plane perpendicular to the meridian of the point, and consequently bisecting the equatorial plane of the spheroid: it is obvious, that, if the elevations on the opposite sides of the plane be equal at the corresponding points of each circle, no lateral force will be produced; but when they are unequal, the excess of the elevated matter on one side above that of the other side will produce a disturbing or lateral force. Now, the elevation being everywhere as the square of the distance x from the equatorial plane, we may call it ex^2, and the difference, corresponding to any point of that semicircle, which is the nearer to the pole of the spheroid, will be $e(x'^2 - x''^2) = e(x' + x'')(x' - x'')$. But $x' + x''$ is always twice the distance of the centre of the supposed circle from the equatorial plane; and the distance of this centre from that of the sphere will be $\cos\psi$, if ψ be the angular distance of the circle from its pole; and calling φ the distance of this pole, from the equatorial plane of the spheroid, the distance in question will be $\cos\psi \sin\varphi$, and $x' + x'' = 2 \cos\psi \sin\varphi$: and the difference $x' - x''$ is twice the actual sine of the arc θ in the supposed circle, that is, twice the natural sine, reduced in the ratio of unit to the radius of this circle, which is $\sin\psi$, reduced again to a direction perpendicular to the equatorial plane; whence $x' - x'' = 2 \sin\theta \sin\psi \cos\varphi$: and $x'^2 - x''^2 = 4 \sin\theta \sin\cos\psi \sin\cos\varphi$. Hence it follows, that, in different positions of the gravitating particle, the effective elevation at each point of the surface, similarly situated with respect to it, is as the product of the sine and cosine of its angular distance φ from the equatorial plane, the other quantities concerned remaining the same in all positions. But the inclination of the surface of the spheroid, as well as the original disturbing force, varies in the same proportion of the product of the sine and cosine of the distance φ: consequently, the sum of this disturbing attraction and the original force will also vary as the inclination of the surface, and may be in equilibrium with the tendency to descend towards the centre, provided that the ellipticity be duly commensurate to the density of the elevated parts.

Now, in order to find the actual magnitude of the disturbing attraction for a shell of given density, we must compute the fluent of $4 e \sin\theta d\theta \sin\cos\psi d\psi \sin\cos\varphi$, reduced first according to the distance and direction of each particle from the given gravitating particle; and we must compare the fluent with $\frac{4}{3}\pi$, the attraction of the whole sphere at the distance of the radius or unity. But for the angle θ, the portion of the force acting in the common direction of $\sin\theta$ is to the whole attraction at the same distance as $\sin\theta$ to 1, so that the attractive force of any point of the semicircle will be $4e \sin^2\theta \sin\cos\psi \sin\cos\varphi$, and its fluxion will be as $\sin^2\theta d\theta$, of which the fluent is $\frac{1}{2}\theta - \frac{1}{2}\sin\cos\theta$, or when $\theta = 180°$, $\frac{1}{2}\pi$, and $\frac{1}{2}\pi \sin\psi$ will express the effect of the disturbing attraction of the semicircles, of which $\sin\psi$ is the radius, reduced to the direction of the middle point, of which the distance is $2 \sin\frac{1}{2}\psi$: the reduction for this distance is as its square to 1; and for the direction, as the distance to $\sin\psi$, together making the ratio of $\frac{\sin\psi}{8 \sin^3 \frac{1}{2}\psi}$, and the ultimate fluxion of the force will be $2e\pi \sin\psi \sin\cos\varphi \sin\cos\psi \frac{\sin\psi}{8 \sin^3\frac{1}{2}\psi}$, $d\psi = 2e\pi \frac{\sin^3\psi \cos\psi}{8 \sin^3\frac{1}{2}\psi} \sin\cos\varphi d\psi$; but $\sin\psi = 2 \sin\cos\frac{1}{2}\psi$, and the fraction becomes $\frac{8 \sin^3 \cos^3\frac{1}{2}\psi}{8 \sin^3\frac{1}{2}\psi} \cos\psi = \cos^3\frac{1}{2}\psi \cos\psi = \cos^3\frac{1}{2}\psi (\cos^2\frac{1}{2}\psi - \sin^2\frac{1}{2}\psi) = \cos^5\frac{1}{2}\psi - \cos^5\frac{1}{2}\psi + \cos^5\frac{1}{2}\psi = 2\cos^5\frac{1}{2}\psi - \cos^3\frac{1}{2}\psi$. Now, taking the fluent from $\psi = 0$ to $\psi = 180°$, we have $2 \int' \cos^5\frac{1}{2}\psi 2d\frac{1}{2}\psi = \frac{8}{5}\cdot\frac{4}{3}$, and $\int' \cos^3\frac{1}{2}\psi \times 2d\frac{1}{2}\psi = \frac{4}{3}$, (Art. Fluents, n. 361, 359): the difference being $\frac{3}{5}\cdot\frac{4}{3} = \frac{4}{5}$, whence the fluent of the force is found $2e\pi \sin\cos\varphi \times \frac{4}{5} \times \frac{1}{n}$, calling the density of the fluid $\frac{1}{n}$; or, where it is greatest, $\sin\cos\varphi$ being $= \frac{1}{2}$, $\frac{4}{5}\frac{e\pi}{n}$, while the attraction of the sphere itself is $\frac{4}{3}\pi$, which is to $\frac{4}{5}\frac{e\pi}{n}$ as 1 to $\frac{3e}{5n}$; and since the elevation e expresses also the maximum of the relative force of gravity depending on the tangent of the inclination (Theorem B), it is obvious that the disturbing attraction $\frac{3e}{5n}$ must be to the relative force e, as $\frac{3}{n}$ to 5.

Corollary 1. If $n = 1$, as in a homogeneous fluid sphere or spheroid, the disturbing attraction becomes $\frac{3}{5}e$, and this attraction, together with the primitive force f, must express the actual elevation e, or $\frac{3}{5}e + f = e$, whence $f = \frac{2}{5}e$, and $e = \frac{5}{2}f$, giving 2.024 and 5.042 for the magnitude of the solar and lunar tides, when $f = .8097$ and 2.0166 respectively. But this is obviously far from the actual state of the problem.

Corollary 2. Supposing $n=5.4$ (See *Journ. R. I.* Apr. 1820), we have $\frac{3e}{27}+f=e$, and $e=\frac{27}{24}f=\frac{9}{8}f$; so that the height of the primitive tides of an ocean of water, covering the whole surface of the earth, such as it actually is, ought to be .911 for the solar, and 2.27 for the lunar disturbing force: that is, supposing the sea to be without inertia, so as to accommodate itself at once to the form of equilibrium. But, in the actual state of the irregularities of the seas and continents, it is impossible to pay any regard to this secondary force, since the phenomena do not justify us in supposing the general form of the surface of the ocean such as to give rise to it.

Theorem D. [H]. When the horizontal surface of a liquid is elevated or depressed a little at a given point, the effect will be propagated in the manner of a wave, with a velocity equal to that of a heavy body which has fallen through a space equal to half the depth of the fluid, the form of the wave remaining similar to that of the original elevation or depression. *Illustr. Celest. Mech.* 378. p. 318.

Scholium. The demonstration of this theorem implies that water is incompressible, and that the pressure of each particle placed on the surface is instantaneously communicated through the whole depth of the fluid to the bottom. These suppositions are not indeed strictly accurate in any case, but they introduce no sensible error when the surface of the wave similarly affected is large in comparison with the depth of the fluid. A modern author, of celebrity, seems to have taken it for granted, that the pressure is propagated with the same velocity downwards and laterally; at least, if such is not his meaning, he has been somewhat unfortunate in the choice of his expressions; but there seems no reason whatever, why water should communicate force more slowly when it is perfectly confined, than ice would do; and the divergence of the pressure of a certain portion of the surface of water, elevated a little, for example, above the rest, may be compared to the *divergence* of a sound entering into a detached chamber by an aperture of the same size with the given surface, which is probably *small* in comparison with its direct motion, but *equally rapid*, and in both cases depending on the modulus of the elasticity of the medium.

Theorem E. [I]. A wave of a symmetrical form, with a depression equal and similar to its elevation, striking against a solid vertical obstacle, will be reflected, so as to cause a part of the surface, at the distance of one fourth of its whole breadth, to remain at rest; and if there be another opposite obstacle at twice that distance, there may be a perpetual vibration between the surfaces, the middle point having no vertical motion. *Nat. Phil.* I. p. 289. 777.

Scholium 1. The elevation and depression of a spheroid, compared with the surface of the sphere of equal magnitude, exhibits a symmetrical wave in the sense of the proposition: and it is not necessary, that the shores should be very rocky or perpendicular, in order to produce a strong reflection; for, even the vibration of the water in the bottom of a common hemispherical basin is considerably permanent.

Corollary 2. The vibrations of the water supposed to be contained in a canal, following the direction of the equator, and 90° in length, would be synchronous with the passage of a wave 180° in breadth, over any point of a canal of the same depth, and surrounding the whole globe.

Scholium 2. It has been usual to consider the elevation of the tides, as identical with that of an oblong spheroid, measured at its vertex, and therefore as amounting to twice as much as the depression of the same spheroid at the equator, considered in relation to the mean height belonging to a sphere of the same magnitude: but, the supposition is by no means applicable to the case of a globe, covered partially and irregularly with water, so that in almost all cases of actual tides, the elevation must be considered as little if at all greater than the depression, as far as this cause only is concerned; there are, however, some other reasons to expect, that the elevation of the great wave might often arrive at a distant port in somewhat greater force than the depression.

Theorem F. [K]. The oscillations of the sea and of lakes, constituting the tides, are subject to laws exactly similar to those of pendulums capable of performing vibrations in the same time, and suspended from points which are subjected to compound regular vibrations, of which the constituent periods are completed in half a lunar, and half a solar day [or in some particular cases a whole day].

Supposing the surface of the sea to remain at rest, each point of it would become alternately elevated and depressed, in comparison with the situation in which it might remain in equilibrium; its distance from this situation varying according to the regular law of the pendulum (see Theorem B); and like all minute vibrations, it will be actuated by forces indirectly dependent on, and proportional to, this distance; so that it may be compared to a pendulous body remaining at rest in the vertical line, about which its point of suspension vibrates, and will consequently follow the motion of the temporary horizon, in the same manner as the pendulum follows the vibration of its point of suspension, either with a direct or a retrograde motion, according to circumstances, which will be hereafter explained: the operation of the forces concerned being perfectly analogous, whether we consider the simple hydrostatic pressure depending on the elevation, or the horizontal pressure, derived from the inclination of the surface, or the differential force immediately producing elevation and depression, depending on the variation of the horizontal pressure, and proportional to the curvature of the surface. It becomes therefore necessary for the theory of the tides, to investigate minutely the laws of these compound and compulsory vibrations; which, together with the resistances affecting them, will be the subject of the next section.

Sect. III.—*Of the Effects of Resistance in Vibrating Motions, whether Simple or Compound.*

Theorem G. If $dw+Ads+Bsds+Dwds=0$; we have $e^{Ds}\left(w+\frac{B}{D}s+\frac{AD-B}{DD}\right)=c$; hl*e* being=1.

Scholium. For the better understanding of the mode of investigation which will be employed in these propositions, it will be proper to premise some remarks on the investigation of fluxional equations, by means of multipliers. A person, unacquainted with the language of modern mathematicians, would naturally understand, by a "criterion of integrability," some mode of distinguishing an expression that would be integrated, from one that was untractable: while, in fact, this celebrated criterion relates only to the accidental form in which the expression occurs, and not to its essential nature. If we take, for instance, the well known case of the fluxion of $\mathrm{hl}\frac{x}{y}=\mathrm{hl}x-\mathrm{hl}y$, we have $\frac{\mathrm{d}x}{x}-\frac{\mathrm{d}y}{y}=\frac{y\mathrm{d}x-x\mathrm{d}y}{xy}$, and making this $=0$, we have also $y\mathrm{d}x-x\mathrm{d}y=0$; and this expression no longer fulfils the conditions of integrability, until we multiply it again by $\frac{1}{xy}$, and restore it to its perfect form. The direct investigation of such a multiplier is generally attended by insuperable difficulties; and the best expedient, in practical cases, is to examine the results of the employment of such multipliers, as are most likely to be concerned in the problem, with indeterminate coefficients, and to compare them with the equations proposed. In common cases, the finding of fluents, when only one variable quantity is concerned, requires little more than the employment of a Table such as that of Meier Hirsch, or that which constitutes the Article FLUENTS in this *Supplement;* and the demonstration of the truth of the solution is in general furnished at once, for each case, by taking the fluxion of the quantity inserted in the Table as the fluent: but for the separation of different variable quantities, where they are involved with each other, the employment of proper multipliers is one of the most effectual expedients; and it is still more essential to the solution of equations between fluxions of different orders, or their coefficients. Such equations require in general to be compared with some multiple of the exponential quantity e^{mt}, which affords fluxions of successive orders, that have simple relations to each other, especially when $\mathrm{d}t$ is considered as constant. The multiples of sin Ct, and cos Ct, are also very useful in such investigations, and for a similar reason; but the solutions that they afford are commonly less comprehensive than the former; though they are often simpler, and more easily obtained. It is not, however, necessary that the exponent of the multiplier should flow uniformly, as will appear from the first example of a problem which has been solved by Euler in his *Mechanics:* the subsequent examples will possess somewhat more of novelty.

Demonstration. The fluxion of $e^{ns}(w+ps+q)$ is $e^{ns}(\mathrm{d}w+p\mathrm{d}s+(nw+nps+nq)\,\mathrm{d}s)=e^{ns}\mathrm{d}w+(p+nq)\,\mathrm{d}s+ns\mathrm{d}s+nw\mathrm{d}s)$; and comparing with this $e^{ns}(\mathrm{d}w+A\mathrm{d}s+Bs\mathrm{d}s+Dw\mathrm{d}s)$, we have $n=D$, $np=B$, and $p=\frac{B}{n}=\frac{B}{D}$; and, lastly, $p+nq=A, q=\frac{A-p}{n}=\frac{AD-B}{DD}$; consequently the fluxion of $e^{Ds}\left(w+\frac{B}{D}s+\frac{AD-B}{DD}\right)$ is equal to nothing, and that quantity is constant, or equal to c.

Example. Let the given equation be that of a cycloidal pendulum, moving with a resistance proportional to the square of the velocity, or $\frac{\mathrm{dd}s}{\mathrm{d}t^2}+Bs-D\frac{\mathrm{d}s^2}{\mathrm{d}t^2}=0$.

Scholium 2. The space s being supposed to begin at the lowest point of the curve, the fluxion $\mathrm{d}s$ is negative during the descent on the positive side, and the force $\mathrm{dd}s$ is consequently negative, and equal, when there is no resistance, to Bs, B being a positive coefficient, equivalent, in the case of gravitation, to $\frac{2g}{l}$ or $\frac{32}{l}$, l being the length of the pendulum, and g the descent of a falling body in the first second. The coefficient $-D$ is negative, because the resistance acts in a contrary direction to that of the force Bs, as long as s remains positive, and coincides with it on the negative side. But in the return of the pendulum the signs are changed; so that the equation can only be applied to a single vibration: since the two forces in question oppose each other in the same points of the curve in which they before agreed, while the square $\frac{\mathrm{d}s^2}{\mathrm{d}t^2}$ must always remain positive.

Solution. If we multiply the given equation by $\mathrm{d}s$, and make the square of the velocity, or $vv=w=\frac{\mathrm{d}s^2}{\mathrm{d}t^2}$, we have $\mathrm{d}s\frac{\mathrm{dd}s}{\mathrm{d}t^2}+Bs\mathrm{d}s-D\frac{\mathrm{d}s^2}{\mathrm{d}t^2}\mathrm{d}s=0=\frac{1}{2}\mathrm{d}w+Bs\mathrm{d}s-Dw\mathrm{d}s$, and $\mathrm{d}w+2Bs\mathrm{d}s-2Dw\mathrm{d}s=0$; which, compared with the theorem, gives us 0 for A, $2B$ for B, and $-2D$ for D; and the solution becomes $e^{-2Ds}\left(w-\frac{B}{D}s-\frac{B}{2DD}\right)=c$, or $w=\frac{B}{D}s+\frac{B}{2DD}+ce^{2Ds}$; and if $w=0$ when $s=\lambda$, we have $\frac{B}{D}\lambda+\frac{B}{2DD}+ce^{2D\lambda}=0$, or, putting $\frac{B}{D}\lambda+\frac{B}{2DD}=\beta$, $\beta+ce^{2D\lambda}=0$, and $c=-\beta e^{-2D\lambda}$; β being also $=\frac{B\gamma}{2DD}$, if $\gamma=1+2D\lambda$. We may also substitute σ for $\lambda-s$, and ce^{2Ds}, $=-\beta e^{2D(s-\lambda)}$, will become $=-\beta e^{-2D\sigma}$, and $w=\frac{B}{D}s+\frac{B}{2DD}-\beta e^{-2D\sigma}=\frac{B}{2DD}(1-\gamma e^{-2D\sigma}+2Ds)$. Now $e^{-2D\sigma}=1-2D\sigma+2D^2\sigma^2-\frac{4}{3}D^3\sigma^3+$

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$\frac{2}{3}D^4\sigma^4 - \ldots$; and $(1+2D\lambda)\,e^{-2D\sigma} = 1+2D\lambda - 2D\sigma - 4D^2\lambda\sigma + 2D^2\sigma^2 + 4D^3\lambda\sigma^2 - D\frac{4}{3}{}^3\sigma^3 - \ldots$; whence $w = \frac{B}{2DD}\,(2Ds - 2D\,(\lambda-\sigma) + 4D^2\lambda\sigma - 2D^2\sigma\ldots) = \frac{B}{2DD}\,(4D^2\lambda\sigma - 2D^2\sigma^2 - 4D^3\lambda\sigma^2\ldots) = B\,(2\lambda\sigma - \gamma\sigma^2 + \frac{2}{3}D\gamma\sigma^3 - \frac{1}{3}D^2\gamma\sigma^4 + \ldots)$.

Corollary 1. From this solution we obtain the point at which the velocity is greatest; and, by reversing the equation, we may also find the extent of the vibration. For when $dw=0$, we have $Bsds = Dwds$, and $Bs=Dw$, which is the obvious expression of the equality of the resistance to the propelling force. Putting the greatest value of $w=\varkappa$, and the corresponding value of $s=\varsigma$, we have $\varkappa = \frac{B}{D}\varsigma + \frac{B}{2DD} + ce^{2D\varsigma} = \frac{B}{D}\varsigma$, since $B\varsigma = D\varkappa$, and $\frac{B}{2DD} = -ce^{2Ds} = \frac{B\gamma}{2DD}e^{2D(\varsigma-\lambda)}$; whence $\frac{1}{\gamma} = e^{2D(\varsigma-\lambda)}$, and $\gamma = e^{2D(\lambda-\varsigma)}$; consequently $\text{hl}\,\gamma = 2D\,(\lambda-\varsigma) = \text{hl}\,(1+2D\lambda)$, and $2D\varsigma = 2D\lambda - \text{hl}\,(1+2D\lambda)$, and $\varsigma = \frac{1}{2D}\left(2D^2\lambda^2 - \frac{8}{3}D^3\lambda^3 + \ldots\right) = D\lambda^2 - \frac{4}{3}D^2\lambda^3 + \ldots$ And since $\varkappa = \frac{B}{D}\varsigma$, we have $\varkappa = \frac{B}{2DD}(2D\lambda - \text{hl}[1+2D\lambda])$.

Lemma. For the reversion of a series, or of a finite equation, if $z = ax+bx^2+cx^3+\ldots$ we have $x = \frac{1}{a}z - \frac{b}{a^3}z^2 + \frac{2b^2-ac}{a^5}z^3 - \frac{5b^3-5abc+a^2d}{a^7}z^4 + \frac{14b^4-21ab^2c+6a^2bd+3a^2c^2-a^3e}{a^9}z^5 - \ldots$

The proof of this well known formula is the most readily obtained by means of a series with indeterminate coefficients, such as $x = Az+Bz^2+\ldots$, which, by actual involution, and by comparison with the proposed series, will give the required values of the coefficients, as expressed in this Lemma.

Corollary 2. When $w=o$, we obtain from its value, divided by $B\sigma$, the equation $2\lambda = \gamma\sigma - \frac{2}{3}D\gamma\sigma^2 + \frac{1}{3}D^2\gamma\sigma^3 - \ldots$; and by reversing this series, we have $\sigma = \frac{2\lambda}{\gamma} + \frac{8}{3\gamma^2}D\lambda^2 + \frac{40}{9\gamma^3}D^2\lambda^3\ldots$, or $\sigma = 2\lambda - \frac{4}{3}D\lambda^2 + \ldots$; the difference of the arcs of descent and ascent being $\frac{4}{3}D\lambda^2$, and the difference of two successive vibrations $\frac{8}{3}D\lambda^2$, when the resistance is very small; this difference being also $\frac{8}{3}\varsigma$; so that the displacement of the point of greatest velocity is $\frac{3}{8}$ of the difference of the successive vibrations.

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Scholium 2. If K be the value of w when Dw would be equal to the force of gravity, and $DK=Bl=2g$, we have $D=\frac{2g}{K}$, or H being the height from which a body must fall to acquire the velocity $\surd K$, since $K=4gH$, $D=\frac{1}{2H}$, and $2D=\frac{1}{H}$.

Scholium 3. It is natural to imagine that we might obtain the time from the equation expressing the velocity in terms of the space, if we merely expanded the value of $\frac{1}{\surd w}$ into a new series, by means of the Newtonian theorem: but the fluents thus obtained for the expression of the time are deficient in convergency; and a similar difficulty would occur if we expressed σ in terms of w by reversing the series, and divided its fluxion by $\surd w$. The ingenuity of Euler has, however, devised a method of avoiding these inconveniences, by supposing the time to begin at the point where the velocity is a maximum; and it will be necessary, in this investigation, to follow his steps, with some slight variations.

Corollary 3. In order to find the time of vibration, we take $s-\varsigma=\tau$, and $\varkappa - w = z$, then $s=\tau+\varsigma$, $\sigma = \lambda-\varsigma-\tau$, $w = \frac{B}{2DD}(1-\gamma e^{-2D\,(\lambda-\varsigma-\tau)} + 2D[\varsigma+\tau])$, and $\varkappa$ being $=\frac{B}{D}\varsigma$, $z = -\frac{B}{2DD} - \frac{B}{D}\tau + \frac{B\gamma}{2DD}e^{2D(\varsigma-\lambda)}e^{2D\tau}$; but we have seen that $e^{2D}(\varsigma-\lambda) = \frac{1}{\gamma}$, and $-z$ becomes $\frac{B}{2DD} + \frac{B}{D}\tau - \frac{B}{2DD}e^{2D\tau}$, $= \frac{B}{D}\tau - \frac{B}{2DD}\left(2D\tau + 2D^2\tau^2 + \frac{4}{3}D^3\tau^3 + \frac{8}{12}D^4\tau^4 + \ldots\right) = \frac{B}{D}\tau - \frac{B}{D}\tau - B\tau^2 - \frac{2}{3}BD\tau^3 - \ldots = -B\tau^2 - \frac{2}{3}BD\tau^3 - \frac{1}{3}BD^2\tau^4 - \ldots$, and $\frac{z}{B} = \tau^2 + \frac{2}{3}D\tau^3 + \frac{1}{3}D^2\tau^4 + \ldots$ In order to reverse this series, we must put $\frac{z}{B} = y^2$, and $\tau = \text{A}y + \text{B}y^2 + \text{C}y^3 + \ldots$, and by substituting the powers of this series for those of τ in the value of $\frac{z}{B} = y^2 = \tau^2 + \text{P}\tau^3 + \text{Q}\tau^4 + \ldots$, we find $\text{A}=1$, $\text{B}=-\frac{1}{2}\text{P}$, $\text{C}=\frac{5}{8}\text{P}^2 - \frac{1}{2}\text{Q}\ldots$; and $\tau = y - \frac{1}{3}Dy^2 + \frac{1}{9}D^2y^3 - \ldots$ Hence $d\tau = dy -$

$\frac{2}{3}Dydy+\frac{1}{3}D^2y^2dy-\dots$; and this fluxion, divided by the velocity $v=\sqrt{(x-z)}$, will be the fluxion of the time; or, since $d\frac{z}{B}=2ydy$ and $dy=\frac{dz}{2By}=\frac{dz}{2\sqrt{B}\sqrt{z}}$, $dt=\sqrt{\frac{1}{B}}\cdot\frac{dz}{2\sqrt{(xz-zz)}}-\frac{D}{3B}\frac{dz}{\sqrt{(x-z)}}+\frac{D^2}{6B\sqrt{B}}\cdot\frac{zdz}{\sqrt{(xz-zz)}}-\dots$: and the fluent becomes $t=\frac{1}{2\sqrt{B}}\text{ arc } v \sin\frac{2z}{x}-\frac{2D}{3B}\sqrt{(x-z)}+\frac{D^2}{6B\sqrt{B}}\left(\frac{1}{2}x \text{ arc } v \sin\frac{2z}{x}-\sqrt{[xz-z^2]}\right)\dots$; the value of which, taken from $z=0$ to $z=x$, is $2\frac{\pi}{\sqrt{B}}-\frac{2D}{3B}\sqrt{x}+\frac{D^2}{3B\sqrt{B}}(\frac{1}{2}x\pi)\dots$ If we now make τ negative, for the ascent of the pendulum, the coefficients P, R, . . ., B, D, . . ., will change their signs, and the value of t will be $\frac{\pi}{2\sqrt{B}}+\frac{2D}{3B}\sqrt{x}+\frac{D^2}{12B\sqrt{B}}x\pi+\dots$, the sum of both being $\frac{\pi}{\sqrt{B}}+\frac{D^2x\pi}{6B\sqrt{B}}+\dots$, which is the time of a complete vibration, and the difference $\frac{4D}{3B}\sqrt{x}+\dots$ The effect of the resistance on the whole time involves, therefore, only the second and the higher powers of the coefficient of the resistance D; and it also disappears with the arc, as x, the square of the greatest velocity, becomes inconsiderable with respect to the velocity itself, and to the time $\frac{\pi}{\sqrt{B}}$.

THEOREM H. If $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs=0$, dt being constant, we have $e^{mt}(ds+asdt)=c$; m being $=\frac{1}{2}A\pm\sqrt{(\frac{1}{4}A^2-B)}$, and $a=\frac{1}{2}A\mp\sqrt{(\frac{1}{4}A^2-B)}$.

Demonstration. The fluxion of $e^{mt}(ds+asdt)$ is $e^{mt}(d^2s+adsdt+(mds+amsdt)dt)=e^{mt}(d^2s+(a+m)dsdt+amsdt^2)$; and, comparing this fluxion with the proposed equation, we have, for the coefficients, $a+m=A$, and $am=B$; whence $\frac{B}{m}+m=A$, $m^2-Am=-B$, $m=\frac{1}{2}A\pm\sqrt{(\frac{1}{4}A^2-B)}$, and $a=\frac{1}{2}A\mp\sqrt{(\frac{1}{4}A^2-B)}$.

Example. Let the equation proposed be that of a cycloidal pendulum, vibrating with a resistance proportional to the velocity; that is, $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs=0$.

Scholium 1. The resistance is here adequately expressed, in all cases, by the term $A\frac{ds}{dt}$, so that the equation is permanently applicable to the successive vibrations. Thus, in the second descent, on the negative side of the vertical line, Bs being negative, and $-s$ becoming nearer to 0, the fluxion ds is positive, and $A\frac{ds}{dt}$ is of a contrary character to Bs, as it ought to be.

Solution. Since $m=\frac{1}{2}A\pm\sqrt{(\frac{1}{4}A^2-B)}$, and $a=\frac{1}{2}A\mp\sqrt{(\frac{1}{4}A^2-B)}$, it is obvious that the two radical quantities will be either possible or imaginary, accordingly as $\frac{1}{4}A^2$ is greater or less than B.

Case i. If A^2 is greater than $4B$, the resistance being very considerable, the solution becomes $e^{\frac{1}{2}At\pm\sqrt{(\frac{1}{4}A^2-B)}t}\left(\frac{ds}{dt}+[\frac{1}{2}A\mp\sqrt{(\frac{1}{4}A^2-B)}]s\right)=c$; and the velocity $v=-\frac{ds}{dt}=(\frac{1}{2}A-\sqrt{[\frac{1}{4}A^2-B]})s-ce^{-\frac{1}{2}At-\sqrt{(\frac{1}{4}A^2-B)}t}=(\frac{1}{2}A+\sqrt{[\frac{1}{4}A^2-B]})s-c'e^{-\frac{1}{2}At+\sqrt{(\frac{1}{4}A^2-B)}t}$; and if the velocity be supposed to vanish when $s=\lambda$, and $t=0$, we have $0=\frac{1}{2}A\lambda-\sqrt{(\frac{1}{4}A^2-B)}\lambda-c=\frac{1}{2}A\lambda+\sqrt{(\frac{1}{4}A^2-B)}\lambda-c'$.

Corollary 1. Hence it appears that such a pendulum would require an infinite time to descend to the lowest point, since the velocity cannot have a finite value when s vanishes, the exponential quantity never beginning negative.

Scholium 2. The coefficient B may also be written, for an actual pendulum, as measured in English feet, $\frac{32}{l}$, or $\frac{2g}{l}$, if we call g the descent of a falling body in the first second, which is, however, denoted, in the works of some authors, by $\frac{1}{2}g$ or even by $\frac{1}{4}g$. If we make $\frac{dds}{dt^2}+\frac{32}{l}s=0$; when $s=l$, the force becomes such that $-d^2s=32dt^2$, and $-\frac{ds}{dt}=32$, which is the true velocity generated by such a force in a second of time. Supposing k to be the velocity with which the resistance would become equal to the weight, we must have, for $A\frac{ds}{dt}$, $\frac{32}{k}\frac{ds}{dt}$, in order that the force represented by A may become equal to that of gravity, and $A=\frac{2g}{k}$: and if h be the height from which a body must fall to gain the velocity k, since $h=\frac{k^2}{4g}$, $A^2=\frac{4gg}{kk}=\frac{g}{h}$. Hence it follows, that when $A^2=4B$, which is the time of the possibility of alternate vibrations, $\frac{g}{h}=\frac{8g}{l}$, and $h=\frac{1}{8}l$, the resistance becoming equal to the weight when the body has fallen freely through one eighth of the length of the pendulum.

Case ii. Supposing now the resistance to be more moderate, and $\frac{1}{4}A^2$ to be less than B, and making

$B-\frac{1}{4}A^2=C^2$; we shall have $\surd(\frac{1}{4}A^2-B)=\surd(-C^2)=\surd\overline{-1}\,C$; the solution of the equation, $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs=0$, will then be $d\left(e^{\frac{1}{2}At\pm\surd\overline{-1}Ct}\left[\frac{ds}{dt}+\frac{1}{2}As\mp\surd\overline{-1}\,Cs\right]\right)=0$; whence, by taking the two different values in succession, and adding together their halves, we obtain $d\left(e^{\frac{1}{2}At}\left[\frac{e^{\surd\overline{-1}Ct}+e^{-\surd\overline{-1}Ct}}{2}(ds+\frac{1}{2}As)+\frac{e^{-\surd\overline{-1}Ct}-e^{\surd\overline{-1}Ct}}{2}\surd\overline{-1}\,Cs\right]\right)=o$; or, since $\surd\overline{-1}=\frac{-1}{\surd\overline{-1}}$, $\frac{e^{\surd\overline{-1}Ct}+e^{-\surd\overline{-1}Ct}}{2}\left(\frac{ds}{dt}+\frac{1}{2}As\right)+\frac{e^{\surd\overline{-1}Ct}-e^{-\surd\overline{-1}Ct}}{2\surd\overline{-1}}Cs=ce^{-\frac{1}{2}At}$. Now the imaginary exponential quantities, thus combined, are the well known expressions for the sine and cosine of the arc Ct, (*Elem. Illustr.* § 358); and the last equation may be written thus, $\cos Ct\left(\frac{ds}{dt}+\frac{1}{2}As\right)+\sin Ct\, Cs=ce^{-\frac{1}{2}At}$; whence $v=-\frac{ds}{dt}=\frac{1}{2}As+\frac{\sin Ct}{\cos Ct}Cs-\frac{ce^{-\frac{1}{2}At}}{\cos Ct}$. This fluent, if t were made to begin when $v=0$, would only afford us such expressions as have hitherto been found intractable; but nothing obliges us to limit the problem to this condition, and it is equally allowable to make the time t begin when $v=\frac{1}{2}As$, the corresponding value of s being called ς, then $\frac{1}{2}A\varsigma=v=\frac{1}{2}A\varsigma-c$; consequently $c=0$. The equation will then become $\frac{ds}{s}+C\frac{\sin}{\cos}Ct+\frac{1}{2}Adt=0$; whence $\text{hl}\, s-\text{hl}\cos Ct=c'-\frac{1}{2}At=\text{hl}\frac{s}{\cos Ct}$, and $\frac{s}{\cos Ct}=e^{c'-\frac{1}{2}At}$, or $s=\cos Ct.\,e^{c'-\frac{1}{2}At}$; and, when $t=0$, $s=e^{c'}=\varsigma$; consequently $\frac{s}{\varsigma}=\cos Ct.e^{-\frac{1}{2}At}=\cos Ct\left(1-\frac{1}{2}At+\frac{1}{8}A^2t^2-\frac{1}{48}A^3t^3+\ldots\right)$. But, since $v=-ds=s\left(C\frac{\sin}{\cos}Ct.dt+\frac{1}{2}Adt\right)$, it follows that v must vanish whenever $C\frac{\sin}{\cos}Ct+\frac{1}{2}A=0$, or when $\text{ta}\,Ct=\frac{-A}{2C}$, that is, in the first instance, very nearly when $Ct=\frac{-A}{2C}$, and $t=\frac{-A}{2CC}$, and $-\frac{1}{2}At=\frac{AA}{4CC}$, and $e^{-\frac{1}{2}At}=1+\frac{AA}{4CC}$, very nearly; so that, calling the primitive extent of the arc of vibration $s=\lambda$, we have $\frac{\lambda}{\varsigma}=\cos Ct\left(1+\frac{AA}{4CC}\right)$; $\cos Ct$ being also, in this case, $=\surd\left(1-\frac{AA}{4CC}\right)=1-\frac{AA}{8CC}$, and $\frac{\lambda}{\varsigma}=1+\frac{AA}{8CC}$, and $\frac{\varsigma}{\lambda}=\frac{8CC}{8CC+AA}=\frac{8B-2AA}{8B-AA}=1-\frac{AA}{8B-AA}$, corresponding to the verse sine of the time $\frac{-A}{2CC}$, or to the arc $\frac{-A}{2C}$, in the circle represented by Ct.

Corollary 2. It follows that both v and s must vanish continually at equal successive intervals, whenever $\text{ta}\,Ct=\frac{-A}{2C}$, and when $\cos Ct=0$, respectively; the descent, to the lowest point, will therefore occupy the time corresponding to $\frac{\pi}{4}+\frac{A}{2C}$, and the subsequent ascent to $\frac{\pi}{4}-\frac{A}{2C}$: the extent of the vibrations being always proportional to $e^{-\frac{1}{2}At}$.

Corollary 3. The greatest velocity must take place at the point where $A\frac{ds}{dt}+Bs=0$, and $AC\,\text{ta}\,Ct+\frac{1}{2}A^2=B$, or $\text{ta}\,Ct=\frac{B-\frac{1}{2}AA}{AC}$, and $\cot Ct=\frac{AC}{B-\frac{1}{2}AA}$, or, if we neglect A^2, $\cot Ct=\frac{A}{\surd B}=\cos Ct=\frac{s}{\varsigma}$, very nearly.

Corollary 4. The diminution of the successive vibrations is expressed by the multiplier $e^{-\frac{1}{2}At}$, which, when $Ct=2\pi$, the whole circumference, is $1-\frac{A}{C}\pi$, and $\frac{A}{C}\pi\lambda$, or $\frac{A\pi\lambda}{\surd B}$ is the diminution of the value of s when the pendulum returns to the place from which it first set out, that is, the difference between the lengths of two vibrations, each corresponding to a semicircumference, and this difference is to $\frac{A}{\surd B}\varsigma$, or $\frac{A}{\surd B}\lambda$, the displacement of the point of greatest velocity, which measures the greatest resistance, as π to 1, or as 3.1416 to 1. We have seen that, for a resistance varying as the square of the velocity, this proportion was as 8 to 3, or as 2.667 to 1.

Corollary 5. If the pendulum be supposed to vibrate in a second, the unity of time, the diminution of the arc 2λ in each vibration will be $\frac{1}{2}A\times2\lambda$, and the successive lengths will vary as $e^{-\frac{1}{2}A}2\lambda$, $e^{-A}2\lambda$, and so forth: and after the number N of vibrations,

Tides. the extent of the arc will be reduced from 2λ to $e^{-\frac{1}{2}NA}2\lambda$; so that if we make $e^{-\frac{1}{2}NA}=M$, we have $\text{hl}M=-\frac{1}{2}NA$, and $A=\frac{2}{N}\text{hl}\frac{1}{M}$. Thus, if in an hour the vibrations were reduced to $\frac{2}{3}$ of their extent, which is rather more than appears to have happened in any of Captain Kater's experiments, we should have $N=3600$, and $M=\frac{2}{3}$, whence $A=\frac{1}{1800}\times .4054651=.00022526$, and $A^2=.000\,000\,050\,75$; and since $B=\frac{32}{l}=9.81$, $C=\surd(B-\frac{1}{4}A^2)=\surd B\surd\left(1-\frac{AA}{4B}\right)=\surd B\left(1-\frac{AA}{8B}\right)=\surd B\left(1-\frac{AA}{78.5}\right)$; the fraction being only $=.000\,000\,000\,65$; or about one second in 1600 millions; that is in about 50 years.

Scholium 3. Although the isochronism of a pendulum, with a resistance proportional to the velocity, was demonstrated by Newton, yet Euler appears to have failed in his attempts to carry the theory of such vibrations to perfection; for he observes (*Mechan.* II. p. 312), *Etsi ex his appareat, tempora tam ascensuum quam descensuum inter se esse æqualia, tamen determinari non potest, quantum sit tempus sive descensuum sive ascensuum: neque etiam tempora descensuum et ascensuum inter se possunt comparari. Æquatio enim rationem inter* s *et* u *definiens ita est complicata, ut ex ea elementum temporis* $\frac{ds}{u}$, *per unicam variabilem non possit exprimi.*

Scholium 4. In confirmation of the solution that has been here proposed, it may not be superfluous to show the truth of the result in a different manner. Taking $s=\varsigma e^{mt}\cos Ct$, we have $\frac{ds}{dt}=\varsigma e^{mt}(m\cos Ct-C\sin Ct)$, and $\frac{dds}{dt^2}=\varsigma e^{mt}(m^2\cos Ct-Cm\sin Ct-Cm\sin Ct-C^2\cos Ct)$; whence $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs=\varsigma e^{mt}(m^2\cos Ct-2Cm\sin Ct-C^2\cos Ct+Am\cos Ct-AC\sin Ct+B\cos Ct)=0$, and $(m^2-C^2+Am+B)\cos Ct-(2Cm+AC)\sin Ct=0$: an equation which is obviously true when the coefficients of both its terms vanish, and $2Cm=-AC$, or $m=\frac{1}{2}A$; and again $C^2=m^2+Am+B=\frac{1}{4}A^2-\frac{1}{2}A^2+B=B-\frac{1}{4}A^2$. The former mode of investigation is more general, and more strictly analytical; but this latter is of readier application in more complicated cases, and it will hereafter be further pursued.

Lemma. If a moveable body be actuated continually by a force equal to that which acts on a given pendulum, the body being in a state of rest when the pendulum is at the middle of its vibration, the space described in the time of a vibration will be to the length of the pendulum as the circumference of a circle is to its diameter. For the force being represented by cos Ct, or cos x, for the pendulum, it will become sin x with regard to the beginning of the supposed motion, and the velocity, instead of sin x, becomes $-$ cos x, or $1-\cos x$; so that the space, instead of $1-\cos x$, is $x-\sin x$, which, at the end of the semivibration, is $x=\frac{\pi}{2}$, instead of $1-\cos x=1$, the space described by the simple pendulum, which is equal to its length. Tides.

Scholium 5. There is a paradox in the relations of the diminution of the vibration to the distance measuring the greatest resistance, which it will be worth while to consider, in order to guard ourselves against the too hasty adoption of some methods of approximation which appears at first sight unexceptionable. The pendulum, if it set out from a state of rest at the point of greatest resistance, would perform a vibration to the extent of double the distance of that point, or $2\frac{A}{\surd B}\lambda$, the initial force being measured by that distance. Now, when the resistance is very small, its magnitude may be obtained without sensible error from the velocity of the pendulum vibrating without resistance at the corresponding part of the arc; and the velocity may be supposed to vary as sin Ct, and the resistance, in the case of this proposition, as sin Ct or sin x also. Hence it may be inferred, by means of the Lemma, that the whole diminution of the space will be to $\frac{A}{\surd B}\lambda$ as π to 1, or that it will be equal to $\frac{A}{\surd B}\pi\lambda$, which has already been found to be the actual difference of two successive semivibrations. The accuracy of this result, however, must depend on the mutual compensation of its errors; for the approximation supposes, that if the resistance vanished at the lowest point, the subsequent retardation would be such as to diminish the space by the effect of the diminution of the velocity acting uniformly through the remainder of the vibration, while in fact the diminution of the space from this cause would be simply equal to a part of the arc proportional to the diminution of the velocity; since the arc of ascent is simply as the velocity at the lowest point. Hence it is obvious, that the effects of the resistance are too much complicated with the progress of the vibration to allow us to calculate them separately; and, accordingly, when the resistance is as the square of the velocity, or as $\sin^2 x$, the diminution of the velocity is expressed by $\frac{1}{2}x-\frac{1}{2}$ sin cos x, and that of the space by $\frac{1}{4}x^2-\frac{1}{4}\sin^2 x$, which, at the end of a vibration, becomes $\frac{1}{4}\pi^2$ instead of π, that is, since the distance of the point of greatest velocity is here $\varsigma=D\lambda^2$, $\frac{1}{4}\pi^2 D\lambda^2=2.467\,D\lambda^2$, while the more accurate mode of computation has shown that the true diminution of the space is $2.667\,D\lambda^2$. (Theorem G.) If we chose to pursue the mode of approximation here suggested, with accuracy, it would be necessary to consider the resistance as a periodical force acting on a pendulum capable of a synchronous vibration, as hereafter in Theorem K, Schol. 1.

Theorem J. If $\frac{dds}{dt^2}+Bs+M\sin Ft=0$, we may

satisfy the equation by taking $s = \sin(\surd B.t) + \frac{M}{FF-B} \sin Ft$.

Demonstration. The value of s here assigned gives us $\frac{ds}{dt} = \surd B \cos \surd Bt + \frac{MF}{FF-B} \cos Ft$, and $\frac{dds}{dt^2} = -B \sin \surd Bt - \frac{MFF}{FF-B} \sin Ft$; so that $\frac{dds}{dt^2} + Bs = B \sin \surd Bt + \frac{MB}{FF-B} \sin Ft - B \sin \surd Bt - \frac{MFF}{FF-B} \sin Ft = \frac{MB-MFF}{FF-B} \sin Ft = -M \sin Ft$.

Corollary 1. If, in order to generalise this solution, we make $s = \alpha \sin \surd Bt + \beta \cos \surd Bt + \gamma \sin Ft + \varepsilon \cos Ft$, we may take any quantities at pleasure for α and β, according to the conditions of the particular case to be investigated; but ε must be $= o$; that is, the motion will always be compounded of two vibrations, the one dependent on the length of the pendulum, or on the time required for the free vibration, indicated by $\surd Bt$, the other synchronous with Ft, the period of the force denoted by M; the latter only being limited to the condition of beginning and ending with the periodical force.

Corollary 2. In the same manner it may be shown that the addition of any number of separate periodical forces, indicated by the terms $M' \sin F't$, $M'' \sin F''t, \ldots$, will add to the solution the quantities $\frac{M'}{F'F'-B} \sin F't$, $\frac{M''}{F''F''-B} \sin F''t$, and so forth.

Example 1. Supposing a pendulum to be suspended on a vibrating centre, and to pass the vertical line at the same moment with the centre, we may make α and $\beta = 0$, and $s = \frac{M}{FF-B} \sin Ft$ only; the vibration being either direct or reversed accordingly as F is less or greater than $\surd B$, or than $\surd \frac{32}{l}$, which determines the spontaneous vibration of the pendulum.

Example 2. But if the ball of the pendulum be supposed to begin its motion at the moment that the centre of suspension passes the vertical line, we must make $s = \frac{M}{FF-B} (\sin Ft - \cos \surd Bt)$; and the subsequent motion of the pendulum will then be represented by the sum of the sines of two unequal arcs in the same circle; and if these arcs are commensurate with each other, the vibration will ultimately acquire a double extent, and nearly disappear, in a continued succession of periods, provided that no resistance interfere. And the consequences of any other initial conditions may be investigated in a manner nearly similar: thus, if the time of free vibration, under these circumstances, were $\frac{1}{3}$ of the periodical time, the free vibration, in which the motion must be supposed initially retrograde, in order to represent a state of rest by its combination with the fixed vibration, would have arrived at its greatest excursion forwards, after three semivibrations, at the same moment with the fixed vibration, and after three complete vibrations more would be at its greatest distance in the opposite direction, so as to increase every subsequent vibration equally on each side, and permanently to combine the whole extent of the separate arcs of vibration. But in this and in every other similar vibration, beginning from a state of rest in the vertical line; that is, at the point where the periodical force is evanescent, the effect of the free or subordinate vibration with respect to the place of the body will obviously disappear whenever an entire number of semivibrations have been performed.

Corollary 3. The paradox stated in the fourth scholium on the last theorem may be illustrated by means of this proposition, and will serve in its turn to justify the mode of computation here employed in a remarkable manner. It has been observed, in Nicholson's *Journal* for July 1813, that the mode of investigating the effects of variable forces, by resolving them into parts represented by the sines of multiple arcs, and considering the vibrations derived from each term as independent in their progress, but united in their effects, may be applied to the problem of a pendulum vibrating with a resistance proportional to the square of the velocity; and that for this purpose the square of the sine may be represented by the series $\sin^2 x = .8484 \sin x - .1696 \sin 3x - .0244 \sin 5x - .00813 \sin 7x - .0029 \sin 9x - .0013 \sin 11x - \ldots$ Now, if we employ this series for resolving the resistance supposed in theorem G into a number of independent forces, the greatest resistance being measured by $\frac{A}{\surd B}\lambda$, we shall have $.8484 \frac{A}{\surd B}\lambda$ for the part supposed to be simply proportional to the velocity, whence, from theorem H, we have $.8484 \pi \frac{A}{\surd B}\lambda$ for the corresponding diminution of the vibration; that is, $2.6653 \frac{A}{\surd B}\lambda$. But it has been observed, in the preceding corollary, that the *place* of the pendulum will not be at all affected by any subordinate vibration after any entire number of complete semivibrations; and the slight effect of the *velocity* left in consequence of these subordinate vibrations may here be safely neglected, so that $2.6653 \frac{A}{\surd B}\lambda$ may be considered as the whole effect of the resistance with respect to the space described, which differs only by $\frac{1}{2000}$ of the whole from $2.666 \frac{A}{\surd B}\lambda$, the result of the more direct computation of theorem G.

Scholium. An experimental illustration of the accuracy of the theorem may be found in the sympathetic vibrations of clocks, and in that of the inverted pendulum, invented by Mr Hardy, as a test of the steadiness of a support; for since the extent of the regular periodical vibration is measured by $\frac{M}{FF-B}$,

it is evident that, however small the quantity of M may be, it will become very considerable when divided by $FF-B$, as F and $\sqrt{B}$ approach to each other; and accordingly it is observed, that when the inverted pendulum is well adjusted to the rate of a clock, there is no pillar so steady as not to communicate to it a very perceptible motion by its regular, though extremely minute, and otherwise imperceptible change of place.

Theorem K. In order to determine the effect of a periodical force, with a resistance proportional to the velocity, the equation, $\frac{dds}{dt}+A\frac{ds}{dt}+Bs=M\sin Gt=0$, may be satisfied by taking $s=\alpha\sin Gt+\beta\cos Gt$, α being $=\frac{GG-B}{(GG-B)^2+AAGG}M$, and $\beta=\frac{AGM}{(GG-B)^2+AAGG}$; s being also $=\sqrt{(\alpha^2+\beta^2)}\sin\left(Gt+\text{arc ta}\frac{\beta}{\alpha}\right)=\frac{M}{\sqrt{([GG-B]^2+AAGG)}}\sin\left(Gt-\text{arc ta}\frac{AG}{B-GG}\right)$.

Since $s=\alpha\sin Gt+\beta\cos Gt$, $\frac{ds}{dt}=\alpha G\cos Gt-\beta G\sin Gt$, and $\frac{dds}{dt^2}=-\alpha G^2\sin Gt-\beta G^2\cos Gt=-G^2s$; consequently the equation becomes $(B-G^2)(\alpha\sin Gt+\beta\cos Gt)+\alpha AG\cos Gt-\beta AG\sin Gt+M\sin Gt=0$, and $(B-G^2)\alpha-\beta AG+M=0$, and $(B-G^2)\beta+\alpha AG=0$; whence $\frac{\beta}{\alpha}=\frac{AG}{GG-B}$; also $\beta=\frac{M-(GG-B)\alpha}{AG}=\frac{\alpha AG}{GG-B}$ and $(G^2-B)M-(G^2-B)^2\alpha=\alpha A^2G^2$; consequently $\alpha=\frac{(GG-B)M}{(GG-B)^2+A^2G^2}$, and $\beta=\frac{AGM}{(GG-B)^2+A^2G^2}$. And since, in general, if $b=\text{ta B}$, $\sin x+b\cos x=\sqrt{(1+b^2)}\sin(x+\text{B})$; $\sin(x+\text{B})$ being $=\sin x\cos\text{B}+\sin\text{B}\cos x=\cos\text{B}(\sin x+\text{ta B}\cos x)$, and therefore $\sin x+\text{ta B}\cos x=\frac{\sin(x+\text{B})}{\cos\text{B}}=\sin(x+\text{B})\sec\text{B}=\sin(x+\text{B})\sqrt{(1+b^2)}$: it follows that $\alpha\sin Gt+\beta\cos Gt=\alpha\left(\sin Gt+\text{arc ta}\frac{\beta}{\alpha}\right)\sqrt{\left(1+\frac{\beta\beta}{\alpha\alpha}\right)}$; and $\alpha\sqrt{\left(1+\frac{\beta\beta}{\alpha\alpha}\right)}=\sqrt{(\alpha^2+\beta^2)}=\sqrt{\frac{(GG-B)^2+A^2G^2}{([GG-B]^2+A^2G^2)^2}}M=\frac{M}{\sqrt{([GG-B]^2+A^2G^2)}}$.

Corollary. If we put $M\cos Gt$ instead of $M\sin Gt$, we shall have $s=\alpha'\sin Gt+\beta'\cos Gt$; α' being $=\beta=\frac{AGM}{(GG-B)^2+A^2G^2)}$ and $\beta'=-\alpha=\frac{B-GG}{(GG-B)^2+AAGG}M$, and $s=\sqrt{(\alpha'^2+\beta'^2)}\sin\left(Gt+\text{arc ta}\frac{\beta'}{\alpha'}\right)=\sqrt{(\alpha^2+\beta^2)}\sin\left(Gt+\text{arc ta}\frac{B-GG}{AG}\right)$.

Scholium 1. Supposing B to approach very near to G^2, a case very likely to occur in nature, because the effects which are produced, where it is found, will predominate over others, on account of the minuteness of the divisor; we may neglect the part of the denominator $(G^2-B)^2$, in comparison with A^2G^2, and the coefficient determining s will then become $\frac{M}{AG}$, the extent of the vibrations being inversely as A the coefficient of the resistance; and, indeed, when the whole force of the periodical vibration is expended in overcoming a resistance proportional to the velocity, it may naturally be imagined that the velocity should be inversely as the resistance. It follows also from the proposition, that in this case the arc ta $\frac{AG}{B-GG}$ approaching to a quadrant, the greatest excursions of the periodical motion and of the free vibration will differ nearly one fourth of the time of a complete vibration from each other.

Scholium 2. Since s is a line, and B its numerical coefficient, making it represent a force, and since $\sin Gt$ is properly a number also, the coefficient M, both here and in Theorem J, must be supposed to include another linear coefficient, as μ, which converts the sine into a line, to be added to s, the distance from the middle point: that is, M must be considered as representing $B\mu$, in which μ is the true extent of the periodical change of the centre of suspension, and $B=\frac{2g}{l}$, as in other cases: so that M is $=\frac{2g}{l}\mu=32\frac{\mu}{l}$, and $\mu=\frac{Ml}{2g}=\frac{1}{32}Ml$.

Corollary. In order to obtain a more general solution of the problem, we may combine the periodical motion thus determined with the free vibrations, as computed in Theorem H, the different motions, as well as the resistances, being totally independent of each other; but the most interesting cases are those which are simply periodical, the free vibration gradually diminishing, with the multiplier e^{-mt}, and ultimately disappearing.

Theorem L. If there are several periodical forces, the equation, $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs+M\sin Gt+N\sin Ft+\ldots=0$, may be satisfied by taking $s=\alpha\sin Gt+\beta\cos Gt+\alpha'\sin Ft+\beta'\cos Ft+\ldots=$

$$\frac{M}{\sqrt{([G^2-B]^2+A^2G^2)}}\sin\left(Gt-\text{arc ta}\frac{AG}{B-GG}\right)+\frac{N}{\sqrt{([F-B]^2+A^2F^2)}}\sin\left(Ft-\text{arc ta}\frac{AF}{B-FF}\right)+\ldots$$

For, the equations expressing the space described being simply linear, the different motions and resistances are added or subtracted without any alteration of the respective relations and effects.

Scholium. A free vibration may also be combined with this compound periodical vibration, by means of Theorem H; but it will gradually disappear by the effect of the resistance.

Lemma. For the addition of the arcs a and b, beginning with the well known equation $\sin(a\pm b)=\sin a\cos b\pm\sin b\cos a$, we have, by addition, $\sin(a+b)+\sin(a-b)=2\sin a\cos b$, and $\sin a\cos b=\frac{1}{2}\sin(a+b)+\frac{1}{2}\sin(a-b)$: then if $c=b+90°$, $\cos b=\sin c$, whence $\sin a\sin c=\frac{1}{2}\sin(a+c-90°)+\frac{1}{2}\sin(a-c+90°)$: but $\sin(x+90°)=\cos x$ and $\sin(x-90°)=-\cos x$; consequently $\sin a\sin c=\frac{1}{2}\cos(a-c)-\frac{1}{2}\cos(a+c)$; again, if $c=a-90°$, $\cos c=\sin a$, and $\cos c\cos b=\frac{1}{2}\sin(a+b)+\frac{1}{2}\sin(a-b)=\frac{1}{2}\sin(c+90°+b)+\frac{1}{2}\sin(c+90°-b)=\frac{1}{2}\cos(c+b)+\frac{1}{2}\cos(c-b)$. Also, since $\cos a\cos b=\frac{1}{2}\cos(a+b)+\frac{1}{2}\cos(a-b)$, and $\sin a\sin b=\frac{1}{2}\cos(a-b)-\frac{1}{2}\cos(a+b)$, we have, by subtraction, $\cos(a+b)=\cos a\cos b-\sin a\sin b$, and, by addition, $\cos(a-b)=\cos a\cos b+\sin a\sin b$.

Corollary. If $a+b=c$ and $a-b=d$, $\cos c+\cos d=2\cos\frac{c+d}{2}\cos\frac{c-d}{2}$; and $\cos d-\cos c=2\sin\frac{c+d}{2}\cos\frac{c-d}{2}$; also $\sin a+\sin b=2\sin\frac{a+b}{2}\cos\frac{a-b}{2}$; and $\sin a-\sin b=\sin a+\sin(-b)=2\sin\frac{a-b}{2}\cos\frac{a+b}{2}$.

Theorem M. The equation, $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs+R\sin Ft\sin Gt=0$ may be solved by taking $s=\alpha\sin([F-G]t+p)-\beta\sin([F+G]t+q)$; α being $\frac{\frac{1}{2}R}{\surd([(F-G)^2-B]^2+A^2(F-G)^2)}$, $\beta=\frac{\frac{1}{2}R}{\surd([(F+G)^2-B]^2+A^2(F+G)^2)}$, $p=$ arc ta $\frac{B-(F-G)^2}{A(F-G)}$, and $q=$ arc ta $\frac{B-(F+G)^2}{A(F+G)}$.

For since $\sin Ft\sin Gt=\frac{1}{2}\cos(F-G)t-\frac{1}{2}\cos(F+G)t$, the equation becomes $\frac{dds}{dt^2}+A\frac{ds}{dt}+Bs-\frac{1}{2}R\cos(F+G)t+\frac{1}{2}R\cos(F-G)t=0$; whence we obtain the solution by comparison with Theorem K and its corollary.

Sect. IV.—*Astronomical Determination of the Periodical Forces which Act on the Sea or on a Lake.*

In order to compute, by means of the theory which has been laid down in the two preceding sections, the primitive tides of any sea or any portion of the ocean, we must compare its spontaneous oscillations with those of a narrow prismatic canal, situated in a given direction with respect to the meridian, which in general must be that of the greatest length of the sea in question, neglecting altogether the actual breadth of the sea, which, if considerable, may require to have its own distinct vibrations compounded with those of the length, each being first computed independently of the other. Now, supposing the time required for the principal spontaneous oscillation of the sea or lake to be known, we must find the length of the synchronous pendulum, and taking $B=\frac{2g}{l}=\frac{32}{l}$, we must next find a series for expressing the force in terms of the sine, or cosines of multiple arcs, increasing uniformly with the time.

Now the force is measured, for the direction of the meridian of the spheroid of equilibrium, by sin cos z, (Theorem A), z being either the zenith distance or the altitude; and it is obvious that, when the canal is situated obliquely with respect to the meridian of the spheroid, the inclination of the surface, and with it the force, will be diminished as the secant of the obliquity increases, or as the cosine of the obliquity diminishes; so that the force will vary as sin cos *Alt.* sin *Az*, if the canal be in an easterly and westerly direction; or if it deviate from that direction in a given angle, as sin cos *Alt.* sin (*Az.*+*Dev.*): and it is obvious that this force will vanish both when the luminary is in the horizon, and when it is in the vertical circle, perpendicular to the direction of the canal; that is, if we consider the force as acting horizontally on a particle at the middle of the length of the given canal; and the same force may be considered as acting vertically, with a proper reduction of its magnitude, at the end of the canal; for the horizontal oscillations at the middle must obviously follow the same laws as the vertical motions at the end.

The case, however, of a canal running east and west, admits a very remarkable simplification; and since it approaches nearly to that of an open ocean, which has been most commonly considered, it will be amply sufficient for the illustration of the present theory. For, in general, sin *Az.* $=\frac{\cos \textit{Decl.}\sin \textit{Hor.}\angle}{\cos \textit{Alt.}}$, and the expression, sin cos *Alt.* sin *Az.*, becomes in this case sin *Alt.* cos *Decl.* sin *Hor.* ∠. But sin *Alt.* = sin (*Lat.*) sin *Decl.* + cos (*Lat.*) cos *Decl.* cos *Hor.* ∠, and calling sin (*Lat.*) for the given canal, L, and cos (*Lat.*), L′, the force becomes L sin cos *Decl.* sin *Hor.* ∠ + L′ $\cos^2$ *Decl.* sin cos *Hor.* ∠. Now, sin *Decl.* = cos *Obl. Ecl.* sin *Lat.* + sin *Obl. Ecl.* cos *Lat.* sin *Long.*; and since $\cos\varphi=1-\frac{1}{2}\sin^2\varphi+\frac{3}{8}\sin^4\varphi-\frac{5}{16}\sin^6\varphi+\ldots$, the true value of cos *Decl.* might be expressed, if required, by means of this series, and its second and fourth powers would in general be sufficient for the computation.

But it will be more convenient to suppose the sun and moon to move in the ecliptic, and the ecliptic to be at the same time so little inclined to the equator, that the longitude may be substituted for the right ascension; a substitution which will cause but little alteration in the common phenomena of the tides. Then if the sun's longitude be ☉, and the moon's

$\rightmoon$, the horary angles t and t', and the sine of the obliquity of the ecliptic $\oe$; we shall have sin *Decl.* $= \oe \sin \odot$, or $\oe \sin \rightmoon$; and $\cos Decl. = 1 - \sin^2 Decl. + \frac{3}{8} \sin^4 Decl. = 1 - \frac{1}{2} \oe^2 \sin^2 \odot + \frac{3}{8} \oe^4 \sin^4 \odot \ldots$, and $\sin \cos Decl. = \oe \sin \odot - \frac{1}{2} \oe^3 \sin^3 \odot + \frac{3}{8} \oe^5 \sin^5 \odot \ldots$; also $\cos^2 Decl. = 1 - \oe^2 \sin^2 \odot$; whence the sun's force becomes $\text{L} \sin t \, (\oe \sin \odot - \frac{1}{2} \oe^3 \sin^3 \odot + \frac{3}{8} \oe^5 \sin^5 \odot \ldots) + \text{L}' \frac{1}{2} \sin 2t \, (1 - \oe^2 \sin^2 \odot) = \text{L} \sin t \left(\oe \sin \odot - \frac{1}{2} \oe^3 \left(\frac{3}{4} \sin \odot - \frac{1}{4} \sin 3 \odot \right) + \frac{3}{8} \oe^5 \left[\frac{5}{8} \sin \odot - \frac{5}{16} \sin 3 \odot + \frac{1}{16} \sin 5 \odot \right] \right) + \frac{1}{2} \text{L}' \sin 2t \, (1 - \frac{1}{2} \oe^2 + \frac{1}{2} \oe^2 \cos 2 \odot) = \text{L} \sin t \, (\oe' \sin \odot + \oe'' \sin 3 \odot + \oe''' \sin 5 \odot) + (\frac{1}{2} \text{L} - \frac{1}{4} \text{L}' \oe^2) \sin 2t + \frac{1}{4} \text{L}' \oe^2 \sin 2t \cos 2 \odot$; $\oe'$ being $= \oe - \frac{3}{8} \oe^3 + \frac{15}{64} \oe^5 \ldots$; or about $.3645$; $\oe'' = \frac{1}{8} \oe^3 - \frac{15}{128} \oe^5 \ldots = .0078$, and $\oe''' = \frac{3}{128} \oe^5 \ldots = .00002$, and $\oe^2 = .1585$. But $\sin t \sin \odot = \frac{1}{2} \cos (t - \odot) - \frac{1}{2} \cos (t + \odot)$, and $\sin 2t \cos 2 \odot = \frac{1}{2} \sin 2 (t + \odot) + \frac{1}{2} \sin 2 (t - \odot)$. Hence the sun's force becomes $S \left(\text{L} \oe' [\frac{1}{2} \cos (t - \odot) - \frac{1}{2} \cos (t + \odot)] + \text{L} \oe'' [\frac{1}{2} \cos (t - 3 \odot) - \frac{1}{2} \cos (t + 3 \odot)] + \text{L} \oe''' [\frac{1}{2} \cos (t - 5 \odot) - \frac{1}{2} \cos (t + 5 \odot)] + \frac{\text{L}'}{2} (1 - \frac{1}{2} \oe^2) \sin 2t + \frac{\text{L}'}{4} \oe^2 [\frac{1}{2} \sin 2 (t + \odot) + \frac{1}{2} \sin 2 (t - \odot)] \right)$: and that of the moon may be expressed in the same manner, by substituting M, t' and $\rightmoon$, for S, t, and $\odot$.

The effect of that part of the hydraulic resistance, which is proportional to the square of the velocity, must be expressed by an approximation deduced from the periodical character of the force, as depending on that of the primitive forces concerned; taking, however, the precaution to use such expressions only, as will always represent this resistance in its proper character as a retarding force: for if we simply found for it an equivalent expression, denoting accurately the square of the velocity, this square, being always positive, would imply a force acting always in the same direction. Now, we have already seen (Theorem J. Cor. 3), that $\sin^2 x$ may be considered, with respect to its principal effect, as equivalent to $.8484 \sin x$: and, if we neglect, in the determination of the resistance, the effect of the smaller forces, and compute only that of the principal terms $\frac{1}{2} \text{L}' \sin 2t$, and $\frac{1}{2} \text{L}' \sin 2t'$, we may call the velocities depending on these forces $S' \cos (2t + s')$ and $M' \cos (2t' + m')$: S' and M' representing not exactly the proportion of the primitive forces of the sun and moon, but that of the tides depending on their combination with the conditions of the given sea or lake. The resistance will then be as the square of $S' [\cos (2t + s') + \cos (2t' + m')] + (M' - S') \cos (2t' + m')$: and when least, it will be $D (M' - S')^2$ and when greatest, $D (M' + S')^2$, the difference being $4DM'S'$; so that the difference may be sufficiently represented by $4DM'S' [\cos (2t + s') + \cos (2t' + m')] \times .8484$, or rather $\times (.8484)^2$, because the value of $\cos t + \cos t' = 2 \cos \frac{t + t'}{2} \cos \frac{t - t'}{2}$, which is to be squared, requires the reduction from 1 to .8484 for each of its factors; and in this manner we obtain a perfect representation of the period and quality of the resistance, and a very near approximation to its magnitude.

It will, however, be still more accurate to consider the resistance thus determined as comprehended in the value of the coefficient A, substituting for it, in the case of the solar tide, $A' = A + 2.88\, DM'$, and for the moon $A'' = A + 2.88\, DS' + .8484\, D (M' - S')$; this latter part expressing that portion of the resistance D which observes the period of the lunar tide, and which may therefore be considered as added to the resistance A for that tide only.

Hence, collecting all the forces concerned into a single equation, the expression will become $\frac{\mathrm{dd}s}{\mathrm{d}t^2} + A^{','\,''} \frac{\mathrm{d}s}{\mathrm{d}t} + Bs + S \left(\text{L} \oe' [\frac{1}{2} \cos (t - \odot) - \frac{1}{2} \cos (t + \odot)] + \text{L} \oe'' [\frac{1}{2} \cos (t - 3 \odot) - \frac{1}{2} \cos (t + 3 \odot)] + \oe''' [\frac{1}{2} \cos (t - 5 \odot) - \frac{1}{2} \cos (t + 5 \odot)] + \frac{\text{L}'}{2} (1 - \oe^2) \sin 2t + \frac{\text{L}'}{4} \oe^2 [{}^{1} \sin 2 (t + \odot) + \frac{1}{2} \sin 2 (t - \odot)] \right) + M \left(\text{L} \oe' [\frac{1}{2} \cos (t' - \rightmoon) - \frac{1}{2} \cos (t' + \rightmoon)] + \text{L} \oe'' [\frac{1}{2} \cos (t - 3 \rightmoon) - \frac{1}{2} \cos (t' + 3 \rightmoon)] + \text{L} \oe''' [\frac{1}{2} \cos (t' - 5 \rightmoon) - \frac{1}{2} \cos (t' + 5 \rightmoon)] + \frac{\text{L}'}{2} (1 - \oe^2) \sin 2t' + \frac{\text{L}'}{4} \oe^2 [\frac{1}{2} \sin 2 (t' + \rightmoon) + \frac{1}{2} \sin 2 (t' - \rightmoon)] \right) = 0$; and from each of these terms the value of the corresponding pair of terms in the value of s may be obtained independently, by comparison with the $M \sin Gt$ or $N \cos Gt$ of Theorem K, which gives us

$$\frac{(GG - B) \sin Gt + AG \cos Gt}{(GG - B)^2 + AAGG} M, \text{ and}$$

$$\frac{AG \sin Gt + (B - GG) \cos Gt}{(GG - B)^2 + AAGG} N, \text{ respectively.}$$

But without entering minutely into the effects of all the terms of the equation of the forces, it may be observed in general that their results, with regard to the space described, will not differ much from the proportion of the forces, except when their periods approach nearly to that of the spontaneous oscillation, represented by B. Thus since $\frac{1}{2} \cos (t - \odot) - \frac{1}{2} \cos (t + \odot)$ is the representative of $\sin t \sin \odot$, and since these terms will afford results in the form $\frac{1}{2} \alpha \cos (t - \odot) + \frac{1}{2} \beta \sin (t - \odot)$, and of $\frac{1}{2} \alpha' \cos (t + \odot) + \frac{1}{2} \beta' \sin (t + \odot)$; and if we neglected the slight difference of α and α', which is that of

$\left(1-\frac{\odot}{t}\right)^2-B$, and $\left(1+\frac{\odot}{t}\right)^2-B$, $\frac{\odot}{t}$ being $\frac{1}{365.254}$ only, we should have $\frac{1}{2}\alpha$ [cos $(t-\alpha)$— cos $(t+\odot)]+\frac{1}{2}\beta$ [sin $(t-\odot)$— sin $(t+\odot)=\alpha \sin t \sin \odot+\beta \cos t \sin \odot=\sin \odot (\alpha \sin t+\beta \cos t)$; which is the same as if we considered the effect of the force sin t separately, and afterwards reduced it in the proportion of sin $\odot$. Hence it is obvious that for all modifications of the forces greatly exceeding in their periods the period of spontaneous oscillation, the effects may be computed as if the forces were exempt from those modifications, and then supposed to be varied in the same proportion as the forces: but we cannot be quite certain of the magnitude of the error thus introduced, unless we know the exact value of B, which determines the time of spontaneous oscillation.

Considering, therefore, in this simple point of view, the correct expression of the force, L sin cos *Decl.* sin *Hor.* $<$+L′ cos ² *Decl.* sin cos *Hor.* $<$, or $\frac{1}{2}$L sin 2 *Decl.* sin *Hor.* $<+\frac{1}{2}$L′ cos ² *Decl.* sin 2 *Hor.* $<$: we may observe that the phenomena for each luminary will be arranged in two principal divisions; the most considerable being represented by $\frac{1}{2}$L′ cos ² *Decl.* sin 2 *Hor.* $<$, and giving a tide every twelve hours, which varies in magnitude as the square of the cosine of the declination varies, increasing and diminishing twice a year, being also proportional to the cosine of the latitude of the place, and disappearing for a sea situated at the pole: the second part is a diurnal tide, proportional to the sine of the latitude of the given canal, being greatest when the luminary is furthest from the equinox, and vanishing when its declination vanishes.

From these general principles, an attentive student may easily trace for himself the agreement of the theory here explained with the various modifications of the tides as they are actually observed, and as they are recorded by Lalande and Laplace, and as they are enumerated in the Article Tides of the late editions of this *Encyclopædia*. It remains, however, for us to inquire more particularly into the cause of the hitherto unintelligible fact, that the maximum of the spring tides in the most exposed situations is at least half a day, if not a whole day, later than the maximum of the moving forces.

Now it is easy to perceive that since the resistance observing the lunar period is more considerable than that which affects the solar tide, the lunar tide will be more retarded or accelerated than the solar; retarded when the oscillation is direct, or when G^2-B is positive, and accelerated when it is inverted, or when that quantity is negative: and that in order to obtain the perfect coincidence of the respective high waters, the moon must be further from the meridian of the place than the sun; so that the greatest direct tides ought to happen a little before the syzygies, and the greatest inverted tides a little after: and from this consideration, as well as from some others, it seems probable that the primitive tides, which affect most of our harbours, are rather inverted than direct.

If we wish to apply this theory with precision to the actual state of the solar and lunar motions, we must determine the value of the coefficients, from the tables of those luminaries: and first, making the unit of time a whole solar day, in which the horary angle t extends from 0° to 360°, the sun's mean longitude $\odot$ will be $\frac{t}{365.254}$ added to the longitude at the given epoch, and the moon's approximate horary angle t' will be found from the variation, or the moon's age in space.

Now, in Burckhardt's *Tables*, p. 87, we find the variation for the midnight ending 1823, by adding the constant quantity 9° to the epoch for 1824, and (11ˢ. 14°. 44′. 44″)+9°=11ˢ. 23°. 44′ 44″, or—(6°. 15′. 16″), according to the time of Paris: the movement for 12 hours is 6°. 5′. 43″; consequently at noon, or 1824 Jan. 1. 0h, astronomical time at Paris, the variation is—(9′. 33″), corresponding to the movement of 18ᵐ. 49 . in mean time, and the mean conjunction will take place at 18ᵐ. 49ˢ. Parisian time, which may be more compendiously expressed by calling it the true mean noon, in the time of the island of Guernsey or of Dorchester: and the movement in 24 hours being 12° 11′ 26.5″=12.19°, we shall have $t'=360°-12.19°=347.81°$ when $t=360°$, or $t'=\frac{347.81}{360}t=.96614t$; and the moon's horary angle, considered in relation to the circumference as unity, will always be $.96614t$, if t be the number of days elapsed, from the noon of 1st Jan. 1814 at Guernsey.

The sun's mean longitude for the same epoch is (279°. 35′. 23.1″)=.77666, his longitude for any other time will therefore be $.77666+.002738t=\odot$, and that of the moon, ☽ $=.77666+.03386t$.

We may compute, with sufficient accuracy, the effect of the modifications produced by the change of the moon's distance, or the inequality of her motion in her orbit, or of the periodical change of the inclination of her orbit to the equator, which takes place from the revolution of the nodes, by simply considering the changes which will be produced in the forces concerned by these inequalities, and supposing the effects simply proportional to their causes. If, however, it were desired to determine these modifications with still greater precision, we might deduce approximate formulas for expressing them from the elements employed in the Tables.

The epoch of the moon's mean anomaly for 1824 is (4ˢ. 29°. 25′. 23.3″)+2°=151°. 25′. 23.3″; the movement for 12ʰ. 18ᵐ. 49ˢ. is (6°. 31′. 57″)+(9′. 47.9″)+27″=6°. 42′. 12″, which gives 158°. 7′. 35″ for the mean anomaly at noon in the island of Guernsey. The daily movement being 13° 3.9′=13.065°, the mean anomaly will always be $158.127°+13.065°t$, reckoning t from the supposed epoch or day. The principal part of the central equation will then be, according to Burckhardt, 22692.4″ sin *An.*, or (6°. 18.2′) sin $(158\frac{1}{8}°+13.065°t)$, and its sine will be very nearly .11 sin $(13.065°t+158.127°)$, which will represent the principal inequality of the longitude and of the variation, so that the variation, instead of $12.19°t$, will become $12.19°t+6.3°$ sin $(13.065°t+158.127°)$, and this subtracted from $360°t$, leaves

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$347.81°t - 6.3°\cdot\sin(13.065°t + 158.127°)$, the sine of which is nearly sin $347.81°t$—cos $347.81°t$ .11 sin $(13.065t + 158.127°)$.

The equatorial parallax is nearly $57' + 187''$ cos *An.*, or $57' + 3.1'$ cos $(13.065°t + 158.127°)$; and the disturbing force, which varies as the cube of the parallax, or of $57'$ $[1 + .0544 \cos(13.065°t + 158.127°)]$ may be expressed, with sufficient accuracy, by $1 + .1632 \cos(13.065°t + 158.127°)$.

The supplement of the node for 1824 is (2.10.56) $+2' = 70°\ 58'$, to which we must add $(3'.10.6'')\ t$ for the time elapsed: and the longitude ☽ will be $279°.\ 35'\ 23.1'' + (13°.\ 10'.\ 35'')\ t$.

Although the value of the coefficient B is not directly discoverable, we may still obtain a tolerable estimate of its magnitude in particular cases, by inquiring into the consequences of assigning to it several different values, equal, for example, to the coefficient of the solar or lunar tide, or greater or less than either; while we assume also, for the coefficient of the resistance, A, a great and a smaller value, for instance $\frac{1}{3}$ and $\frac{1}{10}$, supposing D to be inconsiderable. We then find, from the expression $\sqrt{(\alpha^2+\beta^2)}M = \sqrt{(\alpha^2+\beta^2)}\,B\mu$ (Theorem J, Schol. 2) $= \dfrac{B(S,M)}{\sqrt{[(GG-B)^2+AAGG]}}$, for the solar tide, G being 1, if

$$B = \quad \tfrac{1}{2}, \quad .93442, \quad 1, \text{ or } \quad 4;$$

$$A = \begin{cases} \frac{1}{10}; & -.980, \quad -7.550, \quad 10, \quad 1.3324, \\ \frac{1}{3}; & -.832, \quad -2.742, \quad 3, \quad 1.3252; \end{cases}$$

and for the lunar, G being .96614, and

$$A = \begin{cases} \frac{1}{10}; & -1.122, \quad 10, \quad 8.197, \quad 1.3036, \\ \frac{1}{3}; & -.913, \quad 3, \quad 2.942, \quad 1.2968, \end{cases}$$

respectively.

Hence it appears, that the resistance tends greatly to diminish the variation in the magnitude of the tides, dependent on their near approach to the period of spontaneous oscillation, and the more as the resistance is the more considerable: and supposing, with Laplace, that in the port of Brest, or elsewhere, the comparative magnitude of the tides is altered from the proportion of 5 to 2, which is that of the forces, to the proportion of 3 to 1; the multipliers of the solar and lunar tides being to each other as 5 to 6, we have the equation $\dfrac{36BB}{(1-B)^2+A^2} = \dfrac{25BB}{(n-B)^2+A^2}$, whence we find that B must be either .9380 or .6328; and the former value making the lunar tide only inverse, we must suppose the latter nearer the truth; and the magnitude of the tides will become 1.663 and 1.998: and it appears from the same equations, that, n remaining $= .93442$, A cannot be greater than .632; and B would then be .78540: and if $A = 0$, the values of B would be .9617 or .6091. It seems probable, however, that the primitive tides must be in a somewhat greater ratio than this of 2 to 1 and 5 to 3, when compared with the oscillations of the spheroid of equilibrium; and if we supposed $B = .9$ and A still $= \frac{1}{10}$, we should have 7.071 and 9.756 for their magnitude. Now if $B = .6328$, the tangents of the angular measures of the displacement, $\dfrac{\beta}{\alpha} = \dfrac{AG}{GG-B}$, becomes $\dfrac{.1}{.3672}$ and $\dfrac{.96614}{.30160}$ respectively, giving us 69° 50′ and 72° 40′ for the angles themselves: and if $B = .9$, these angles become 45° and 70° 24′ respectively; the difference in the former case 2° 50′, and in the latter 25° 24′, which corresponds to a motion of more than twenty four hours of the moon in her orbit.

It appears then that, *for this simple reason only*, if the supposed data were correct, the highest spring tides ought to be A DAY LATER than the conjunction and opposition of the luminaries; so that this consideration requires to be combined with that of the effect of a resistance proportional to the square of the velocity, which has already been shown to afford a more general explanation of the same phenomenon. There is indeed little doubt, that if we were provided with a sufficiently correct series of minutely accurate observations on the tides, made not merely with a view to the times of low and high water only, but rather to the heights at the intermediate times, we might form, by degrees, with the assistance of the theory contained in this article only, almost as perfect a set of tables for the motions of the ocean, as we have already obtained for those of the celestial bodies, which are the more immediate objects of the attention of the practical astronomer. There is some reason to hope, that a system of such observations will speedily be set on foot, by a public authority: and it will be necessary, in pursuing the calculation, on the other hand, to extend the formula for the forces to the case of a sea, performing its principal oscillations in a direction oblique to the meridian, as stated in the beginning of this section.

For such a sea, the calculations would be somewhat complicated, except in the case of its being situated at or near the equator: we should then obtain, by proper reduction, for the volume of the force, putting D the sine of the duration, or of the angle formed by the length of the canal with the equator, and D′ its cosine, the expression D sin cos *Decl.* cos *Hor.* $\angle$ + D′ cos² *Decl.* sin cos Hor. $\angle$: and the order of the phenomena would be less affected by the alteration of the situation of the canal than could easily have been supposed, without entering into the computation. This expression, when D=O, becomes, as it ought to do, identical with the former, making L=O. (A. L.)

Situation.

TIPPERARY, an extensive county in the province of Munster in Ireland, bounded by King's and Queen's Counties on the north; Kilkenny on the east; Waterford and Cork on the south; and Galway, Clare, and Limerick, on the west. From Galway and Clare it is separated by the Shannon, which forms the boundary on the south-west. It extends about 74 miles from north to south, and 40 from east to west, containing 1591 English square miles, or 1,018,240 acres, 12 baronies, and 186 parishes. More than half the parishes belong to the Archbishopric of Cashel, and the rest to the sees of Emly, Lismore, and Killaloe.

Extent.

Surface.

The surface is considerably diversified with moun-

Tipperary. tains, some of them covered with heath, and plains of great fertility, of which, however, the latter occupy the larger portion, the former being chiefly confined to the boundaries, or not stretching far into the interior. Among these the Galties and Knockmeledown are the most considerable. The rest of the county is in general very productive; and contains some large tracts, particularly that which is called the *Golden Vale*, and the quarter in which the town of Tipperary is situated, naturally as rich as any land in the United Kingdom. The rivers are the Shannon, which here expands into the noble lake called Lough Derg, and the Suir, which, rising on the borders of King's County, takes its course first south and then east by Clonmel and Carrick, and after joining the Barrow and the Nore, falls into the sea upwards of 100 miles from its source. Many small streams traverse the county, and are lost in these two rivers. Among the minerals are excellent slate in several parts, and lead wrought at Silver Mines on the western side of the county, among the ore of which some virgin silver has been found. Coal is also worked here, on the borders of Queen's County. The climate is so mild, that cattle remain out on their pastures all the year round, the frosts of winter being seldom so severe as greatly to check vegetation.

Rivers.

Minerals.

Estates. This county is divided into estates of various sizes, some of them very large, but a greater number of a medium extent, worth from L. 4000 to L. 6000 a-year. Of the proprietors, the influence of Lord Landaff is by far the most considerable, though several others have estates worth from L. 10,000 to L. 15,000 a-year and upwards. The graziers here, as in Roscommon, have leasehold properties frequently of much greater value than the freeholds, of which also they often become the purchasers. Properties of this description, worth from L. 2000 to L. 4000 a-year, are very common. Tillage farms, however, are generally of small extent, one of ninety Irish acres being thought large; yet the management is in many instances more respectable than in most other parts of Ireland. In some instances the rent of small farms in 1808 was as high as fourteen guineas the Irish acre. But the principal business is grazing, every variety of this kind of land being found here. Leases are commonly for twenty-one years and a life. The cattle, which are long-horned, may be ranked with the best in Ireland, and many of the fine flocks of long-wooled sheep are not inferior, in Mr Wakefield's opinion, to those of Leicestershire. "The charge for tithe," says the author of the *Statistical Account of the Parish of Carrick*, written in 1815, "is, for wheat 12s., oats 8s., barley 12s., potatoes 12s., meadow 8s., sallows 12s., orchards *ad valorem*, which are always compounded, and never taken in kind." The rich lands produce a kind of flax very different from that which is raised in the north; it grows to a great height, and appears to be exceedingly well adapted for sail-cloth.

Farms.

Tithes.

Flax.

Towns. The principal towns are Clonmel, the county town, and the birth-place of Sterne, and Carrick, both upon the Suir, Cashel, Fethard, formerly a walled town, but now in a state of decay, Cahir, Thurles, Roscrea, Nenagh, and Tipperary, the last now in a ruinous condition.

Manufactures. The manufacture of broad-cloth is carried on to some extent at Carrick; and that of linen, worsted, and coarse woollens, as branches of domestic industry. But the wealth of this extensive district chiefly consists in its cattle and sheep, corn, and other land produce. By means of the Suir, it has access to Waterford and the sea on the south, and by the Barrow and Nore, and a branch of the Grand Canal, to Dublin on the east.

Tipperary ‖ Tooke.

Representation. Tipperary sends four members to Parliament; two for the county, in which there are about 12,000 freeholders, and one for each of the burghs of Clonmel and Cashel. Before the Union the number was eight; Cashel, Clonmel, and Fethard, having each two representatives, and the county two. In 1791, the population was estimated at 169,000; by the census of 1821 it was found to be 353,402. According to Mr Wakefield, the number of Protestants is very small; in some places not one in a hundred. The Irish language is still spoken as well as the English. From the want of bog in the low grounds, turf for fuel is sometimes scarce and dear. The wages of common labour, a few years ago, were higher than in most other parts of Ireland; yet the lower classes have been but too ready to take an active part in the disturbances which frequently bring disgrace and misery on the south of Ireland.

Population.

See the general works quoted under the former Irish counties. (A.)

TITHES. See TAXATION, p. 629.

TOOKE (JOHN HORNE), an ingenious grammarian and an active politician, born in Westminster, June 1736, was the son of Mr John Horne, a tradesman living in Newport Market.

He was the third of seven children; but his father, having acquired considerable affluence, sent him first for a short time to Westminster School, and then to Eton, where he remained five or six years without particularly distinguishing himself, and was removed sooner than had been intended on account of the accidental loss of an eye. He went, in 1755, to St John's College, Cambridge, and took a degree of Bachelor of Arts there. He then became an usher in a school at Blackheath, kept by Mr Jennings; but he was soon after induced by his father to take deacon's orders, and obtained a curacy in Kent. His own preference, however, was so much in favour of the law, that in 1756 he entered as a student of the Middle Temple; but in 1760 he was persuaded to return to the church, and to receive ordination as a priest; and he officiated for three years in the chapelry of New Brentford, which his father had purchased for him; performing his duties with decency, and taking some pains to study the elements of medicine for the sake of the poorer members of his congregation. He then went as tutor to France with the son of Mr Elwes, a gentleman of Berkshire, well known for his riches and his economy.

In 1765, he commenced his political career by writing an anonymous pamphlet in defence of Wilkes and his party. He returned to the continent, and made the tour of Italy in company with a Mr Taylor; and at Paris he formed an intimacy with Wilkes himself, who then found it convenient to reside there. He had altogether laid aside his clerical character in these excursions, but he resumed it for a short time after his return: soon, however, he relap-

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sed into his political amusements; exerting himself, with some success, in various elections, as a partisan of his friend Wilkes, and taking up the cause of a Mrs Bigby, in the pursuit of an "appeal of blood," against the murderers of her husband, who were supposed to have obtained a pardon through corrupt interest with the court; though the widow at last disappointed him by accepting a pecuniary compensation for her right of appeal. He was, however, successful, on his own behalf, in repelling a prosecution for a libel on Mr Onslow; and he gained some credit with a party in the city by suggesting to Beckford, then Lord Mayor of London, the reply which he made to the King's answer to their remonstrance, and which may still be seen, engraved on the pedestal of Beckford's statue in Guildhall. He was soon after very active in establishing the Society for supporting the Bill of Rights, and in obtaining the liberation of Bingley, the printer, who had been somewhat hastily committed to prison by Lord Mansfield.

He had reason to be dissatisfied, in the year 1770, with the conduct of Wilkes, in some pecuniary transactions relating to the Society for the Bill of Rights: both parties appeared to the public in a light somewhat ridiculous on the occasion, and neither of them gained in respectability, though the Society did not appear to value Wilkes the less for the exposures that took place; it was, however, shortly after dissolved, and most of its members, except the particular friends of Wilkes, were incorporated into the Constitutional Society. The next year, Mr Tooke completed his academical course at Cambridge, by taking the degree of Master of Arts, though not without some opposition. He exerted himself greatly about this time, in procuring the publication of the debates of the House of Commons in the daily papers, notwithstanding the well-known standing Orders of the House; and so far as he was instrumental in carrying this point, he appears to have rendered at least one very essential service to his country; but Wilkes, and especially Almon, the bookseller, are said to have a still stronger claim to the merit of this transaction, whatever may have been its character.

He had also a sharp contest with the anonymous "Junius," against whose hasty attack he defended himself with great spirit and energy, and with unexampled success. In 1773, he made a formal resignation of his living, and meant at the same time completely to lay aside his clerical character, though no person seems to have felt himself authorised to accept this part of his resignation; and he began to study the law very diligently, intending to make it the occupation of his life. He adopted soon after a singular method of forcing himself upon the notice of the public, and of the House of Commons in particular: an inclosure bill being about to be hurried, as was reported, a little too rapidly through the House, he wrote some paragraphs in a newspaper, which reflected very severely on the conduct of the Speaker, on purpose that he might be summoned to appear before the House; and being placed at the bar, he gave such reasons for his conduct as produced some animated discussions, and in the end was supposed, though probably without foundation, to have caused the bill to be modified in some oppressive clauses. By these means he obtained the favour of Mr Tooke of Purley, who thought himself aggrieved by the bill in its original state, and received from him such assurances of testamentary favours as induced his nephew, Colonel Harwood, to agree upon a partition of their joint interest in the reversion of his estate; though Mr Horne never received, first and last, more than L. 8000 from the property, notwithstanding the subsequent change of his name about the year 1782, in acknowledgment of his patron's kindness, and his long continued intimacy and frequent residence at Purley; the principal legatee, after all, being a Mr Beaseley.

Mr Horne Tooke was, of course, a strenuous opposer of the American war; and in 1777, he published a very offensive advertisement, in which the sufferers in the battle of Lexington were described as having been murdered by the King's troops. For this attack on the Government, he was tried at Guildhall, in July 1777; he conducted his own defence, but he was found guilty of the libel, and sentenced to a year's imprisonment in the King's Bench, and a fine of L. 200. It was on this occasion that he first appeared before the public as a grammarian, in the criticisms which constitute his celebrated *Letter to Mr Dunning*. The next year he suffered a still severer punishment, in the refusal of the society of the Inner Temple to admit him to the bar, on account of his having taken orders; so that his prospects of professional advancement were utterly annihilated. This occurrence made him still more bitter against the existing Government, and in 1780 he printed some severe remarks upon the measures of Lord North. He attempted to establish himself as a practical farmer in Huntingdonshire; but he caught an ague, and soon became disgusted with an agricultural life; he returned to London, and occupied for some years a house near Soho Square. His ideas of Parliamentary reform, contained in a second letter addressed to Mr Dunning, were by no means extravagant, and he continued to adhere, in this respect, rather to the party of Mr Pitt than to that of Mr Fox.

The publication of his grammatical dissertations, under the title of the *Diversions of Purley*, afforded but a slight and imperfect intermission of his political pursuits, for his etymological works are as replete with the politics of the day as his speeches and his pamphlets; another of which appeared in 1788, under the title of *Two Pair of Portraits*, being intended to serve the cause of Pitt's party in their elections. But in 1790 he became himself a candidate for the representation of Westminster, in opposition to Mr Fox and to Lord Hood; and he distinguished himself sufficiently as a popular orator, though he was not successful in the contest.

He was tried, in 1794, for High Treason, together with several other members of the Corresponding Societies, who had been active in attempting to introduce some imitations of the French Revolution in the plans of reform which they brought forward. He exhibited on the trial somewhat more of firmness than of good taste: one of his associates had before been acquitted, and the jury speedily returned a similar verdict with respect to himself. He after-

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wards dedicated the second volume of his *Diversions of Purley* to his counsel, Gibbs and Erskine, and to the jury who tried him.

In 1796, he again became a candidate for the representation of Westminster; but again without success: and, notwithstanding his strong opinions respecting a reform in Parliament, he afterwards condescended to accept from Lord Camelford, in 1801, a seat for the nominal burgh of Old Sarum. It was then to be determined if a clergyman could sit in the House of Commons; but the ministry, instead of contesting the point with respect to his particular case, brought in a bill to decide the question in the negative for the future, and he remained in the House till the dissolution of the Parliament in the next year, but without particularly distinguishing himself in its proceedings.

His last public effort, as a party man, was made in espousing for a short time the cause of Mr Paull, as candidate for Westminster; but, he abandoned this gentleman in a subsequent contest. The later years of his life were chiefly passed in the society of a select circle of friends, who frequently partook of his hospitality at Wimbledon. He died in March 1822, leaving his property to some natural daughters; for he had never been married. He was buried in Ealing church, and not in his garden, as he had directed; his executors thinking themselves the less bound by these instructions, as a literal compliance with them might have been unfavourable to the "sale" of the property.

1. His earliest publication was a pamphlet entitled *The Petition of an Englishman*, 1765. It consisted principally of apologies, for the private conduct and immoral writings of Wilkes.

2. He also published *A Sermon* while he continued in the church, that is, before the year 1773: but it attracted little notice.

3. *A Letter to Mr Dunning*, 1778. The rudiments of his grammatical system, arising out of remarks on the particles employed by the Attorney-General in his indictment, and by the judges in his sentence: it was afterwards incorporated into the *Diversions of Purley*.

4. *Facts*, 1780: consisting of remarks on the administration of Lord North; with some additions relating to finance, by Dr Price.

5. *A Letter on Parliamentary Reform*, 1782: addressed to Mr Dunning, afterwards Lord Ashburton.

6. Epea Pteroenta, or *Diversions of Purley*, 8. 1786. Ed. 2. 4. Part I. 1798. Part II. 1802. His great and celebrated work: rich indeed in etymology and in wit, but meagre in definition and in metaphysics.

7. *A Letter to the Prince of Wales*, 1787: relating to the supposed marriage with a Catholic.

8. *Two Pair of Portraits*, 8. 1788. The two Pitts contrasted, in opposite columns, with the two Foxes, in colours by no means favourable to the latter.

9. Many of his *Letters* have been printed in Stephens's *Life of Tooke*, 2 v. 8. Lond. 1813.

It is from the last mentioned publication, that this historical sketch of Mr Tooke's life has principally been extracted: it now becomes necessary to add some remarks on his literary and moral qualifications; and in both these points of view, the subject has been treated in so masterly a manner by the author of an article in the *Quarterly Review*, who is supposed to be a near relation of Tooke's most intimate friend, the late Colonel Bosville, that it would be presumption in any man to go over the same ground, without adopting very nearly the eloquent and energetic expressions, which that noble and learned person has employed.

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"Mr Tooke," says the accomplished Reviewer of the *Memoirs of his Life* (*Q. R.* Vol. VII. No. xiv. p. 325), "was possessed of considerable learning, as indeed his writings sufficiently show. To other more casual acquirements, he united a very extensive acquaintance with the Gothic dialects, of which he has so copiously and so judiciously availed himself in his etymological researches." But it must be remarked, that a person more intimately acquainted with the "Gothic dialects" as living languages will easily discover, that his knowledge of them was in truth but superficial, or that he was indebted for it more to grammars and dictionaries, than to any extensive study of the authors who had written in those languages, or to any habit of speaking them; and such a person will easily find a variety of instances, in which a very different etymon to that which he has assigned, will naturally suggest itself as the true origin of the word in question.

(P. 320.) "Though Mr Tooke's philosophical works are the results of no common talent and industry, yet they are neither written in a truly philosophical spirit, nor do they display traces of a mind, which, even if it had been wholly dedicated to the study of metaphysics, would have much enlarged the bounds of our knowledge in that nice and intricate branch of science. His object seems to have been rather to retard, than to advance the progress of philosophy, by recalling us from those sound conclusions as to the nature and operations of the human mind, which are built upon observation and experience, to vague speculations, drawn from the imperfect analogy existing between the moral and the physical world. There can be no doubt, that the proposition, which he has succeeded in establishing, is highly interesting and important; and that, in the illustration of it, he has shown great learning, ingenuity, and research. But then, on the other hand, he has so monstrously exaggerated its importance, and so widely mistaken its tendency, and has attempted to raise so vast a superstructure upon such a narrow, slippery, and inadequate foundation, that we are quite lost in amazement, when we recollect how completely the sagacity, which guided him so well in the investigation of his principal fact, appears to desert him, when he comes to apply that fact to the purposes of a theory. The distance between what he has proved, and what he wishes us to believe that he has proved, is enormous. What he has proved is, that all words, even those that are expressive of the nicest operations of our minds, were originally borrowed from the objects of external perception; a circumstance highly curious in the history of language, consequently in the

history of the human mind itself, and the complete demonstration of which, of course, reflects great credit upon its author. What he thinks he has proved is, that this etymological history of words is our true guide, both as to the *present* import of the words themselves, and as to the nature of those things, which they are intended to signify: a proposition so monstrous, that he has no where ventured to enunciate it in its general form, but has rather left it to be collected from the tenor of his remarks upon particular instances. In truth, the inferences at which Mr Tooke arrived, far from being warranted by his facts, are directly the contrary of those to which he ought naturally to have been led by the result of his own studies, when they were most successful. In tracing upwards, through all the mazes of etymology, the origin of words, he ought to have seen more clearly, if possible, than any body else, that their *real present* sense is not to be sought for in their primitive signification, or in the elements of which they were originally composed, but that, on the contrary, their *actual import*, with which alone in reasoning we have to do, hardly ever corresponds with their etymological meaning, although the one always bears to the other a certain resemblance, more or less accurate, according to the greater or less effect of time and accident. One could without difficulty understand, how a person, unaccustomed to such considerations, and misled by a few instances partially chosen, should adopt a theory like that which Mr Tooke was desirous to establish; but how a philosopher, minutely acquainted with the whole subject, and proceeding upon a most copious induction of particulars, should not have perceived that, in ninety-nine instances out of a hundred, such a doctrine would lead to absolute absurdity, is, to us at least, inconceivable."

The Reviewer then follows Mr Dugald Stewart in some very just criticisms, which this acute metaphysician had already made on several of Mr Tooke's examples, fully proving the complete fallacy of the system which so completely confounds the definition of a term with its etymology. Mr Tooke has, indeed, the merit of having demonstrated pretty clearly that all the parts of speech, including those which grammarians had often considered as expletives and unmeaning particles, may be resolved more or less completely into nouns and verbs: but on the one hand it has been observed, that the very same doctrine may be clearly traced back to the works of Aristotle; and on the other, it may be asserted with equal truth, if we wish to carry the theory to its utmost extent, that language consists only of nouns and *one verb*: since all verbs may in fact be resolved into participles, or adjectives, compounded with auxiliary verbs, as well as those which exhibit this complication in their exterior form.

"In the ordinary intercourse of life," Mr Tooke "was kind, friendly, and hospitable."—(P. 325.) "We doubt whether his temper was naturally good; but if it was not, he had a merit the more; for he had so completely subdued it by care and self-control, as never to betray, under any provocation, the slightest mark of that irritability which often accompanies talent, and which gains so rapidly upon those who know not how to guard against its approaches. Indeed, the aspect under which he appeared in private was by no means such as the stern cynicism and ferocious turbulence of his public conduct would have led one to expect; and those, whose opinion of him has been formed exclusively upon his political character and his writings, will have some difficulty in believing that the curate of Brentford was one of the best bred gentlemen of the age. In this respect he was a sort of phenomenon. He was born in a low station: at no period did he appear to have possessed any remarkable advantages for the study of good breeding; on the contrary, the greater part of his life was spent in constant intercourse with coarse, vulgar, and uneducated men; yet his natural taste was so good, and he had profited so judiciously by whatever opportunities he enjoyed, that courts and high stations have seldom produced a better example of polite and elegant behaviour, than was exhibited by the associate of Messrs Hardy and Thelwall. Indeed, his manner had almost every excellence that manner can display: grace, vivacity, frankness, dignity. Perhaps, indeed, in its outward forms, and in that which is purely conventional, his courtesy wore the air of the 'vieille cour,' and was rather more elaborate, than is consistent with the practice of this lounging unceremonious age; but it was never forced or constrained, and it sat not ungracefully upon an old man." It may, however, deserve to be remarked, in contemplating this paradox, though rather as a collateral coincidence than as a satisfactory explanation, that even from his infancy Tooke had actually seen something of the very highest society, having been admitted once or twice a week at Leicester House as a play-fellow to the late King: and though he may have learned but little from imitation of the manners of the young Prince, yet the early habit of self-restraint, imposed by such a presence, may easily have imprinted some courtly traces on his character, which were not easily effaced, and which an association with the heirs of the first families of the kingdom, throughout his boyhood, at Westminster and at Eton, must naturally have made still more distinct and permanent.

"He never appeared to greater advantage than in conversation." "He possessed an inexhaustible fund of anecdotes, which he introduced with great skill, and related with neatness, grace, rapidity, and pleasantry: he had a quick sense of the ridiculous, and was a great master of the whole art of raillery, a dangerous talent, though the exercise of it in his hands was always tempered by politeness and good humour."

"In spite of labour and dissipation (p. 328), his life was protracted to a period which indicated an originally sound and vigorous frame. For the last twenty years, however, he was subject to several severe, distressing, and incurable infirmities. These he bore with a patience and firmness which it was impossible not to admire: to the very last he never suffered himself to be beaten down by them, nor ever for one moment indulged in complaint, or gave way to despondency. In the intervals of pain, nay, even when actually suffering under it, he preserved a self-command, which enabled him to converse, not

only with spirit and vigour, but with all his accustomed cheerfulness and pleasantry, never making any demand upon the sympathy of his friends, or mentioning his own situation at all, except when occasionally, and by a very pardonable exercise of his sophistry, he amused himself in exalting its comforts, and explaining away its disadvantages; displaying, in this respect, a manly spirit and a practical philosophy, which, if they had been brought to bear upon his moral, as well as upon his physical condition, if they had been employed with as much effect in reconciling him to his political exclusion as to his bodily sufferings, might have produced, not the very imperfect character we have been attempting to delineate, in which the unfavourable traits bear so large a proportion to those of a nobler and more benign cast, but the venerable portrait of a truly wise and virtuous man."

Reid's *Memoirs*, 8. Lond. 1812; *Quarterly Review*, June 1812; A. Stephens's *Life of Tooke*, 2 v. 8. Lond. 1813; *British Critic*, N. S. Vol. I. p. 79, 193; (Aikin's *General Biography*, IX. 4. Lond. 1814; Chalmers's *Biographical Dictionary*, XXIX. 8. Lond. 1816.) (A. L.)

TURKISH EMPIRE. Although this empire has undergone but slight alterations since the account of it contained in the *Encyclopædia* was written, yet, as its statistics have had some new light thrown on them by recent publications, we shall give a brief sketch of its present state.

Extent.

The extent of this empire has been variously estimated by different writers; and, after consulting them, we rather concur in the calculations made by Hassel, the latest of them, founded on the charts of Reichart and Niedls, because they are corroborated by the last map constructed by Arrowsmith, and by that of Lapiess. In this account of the extent of the empire we have included all those countries over which Turkey claims the sovereignty, although in many of them that sovereignty is either not acknowledged or very feebly exercised.

	Square Miles.
Turkey in Europe contains	180,074
Turkey in Asia on the Continent	436,629
Islands of Turkey in Asia	11,050
The African Dominions	276,480
	904,233

Population.

In countries where no censuses have been taken in modern times, in which no registers of births or deaths are preserved, where no general conscription has been introduced, and where even the number of houses is not known, the accounts of population must be mere estimates or rather conjectures; and, therefore, it is not extraordinary that different writers should have presented results so distant from each other as those we have examined. Two censuses have, indeed, been instituted; one in the middle of the sixteenth, and the other at the beginning of the seventeenth century. Their results are not, however, now known; and if they were, they would scarcely be tolerable guides at this day, when the whole state of affairs has undergone such great alterations. Hassel, in 1816, calculated the whole number of Turkish subjects at 24,070,000; and, in 1819, Lichtenstern estimated them at 24,880,000, whilst Gräberg reckoned them to be in round numbers 23,000,000. Though these industrious writers thus approached nearly to each other in their totals, they differ most widely in the component parts. Thus, in Asia Minor, they disagree to the extent of five or six millions; and in Egypt and its dependancies to the extent of three or four.

Finances.

The financial affairs of the Turkish empire are involved in still greater obscurity than the state of the population. From the system, which uniformly prevails, by which every governor of a province collects imposts, and expends them on the local objects under his management—that which is received into the general treasury bears no proportion to that which is extracted from the subject. Many of the provinces are compelled to deliver contributions in their productions, which productions are appropriated to some specific public department. Thus Egypt was required to deliver to the arsenal 1000 quintals of hemp, 200 jars of oil, 2000 pieces of linen, and 140 quintals of linen yarn; and to the Seraglio 36,000 measures of rice, 45,000 okas of sugar, 2000 measures of pease, besides stipulated quantities of ginger, cinnamon, pepper, and other smaller articles. The other provinces are required in a similar manner to contribute to the demands of the Imperial Government. The annual sum which flows into the treasury has been estimated, by Contemir and Thornton, at about L.3,000,000 Sterling, and by Eton at near L.4,000,000. Whatever may be the amount of the public income, it is distinct from the revenues which accrue to the Emperor personally, of which no account can be obtained; but it is imagined that they amount to much more than the expenditure of the imperial establishment, and that vast sums have been accumulated in the household treasury. These personal revenues arise from domains, from confiscations, from presents, and from the sale of governments and other offices. Count Marcellus, in a work published at the Hague in 1732 (*Stato Militare de Imperio Ottomanno*), asserts, that, at the death of Ibrahim in 1639, his successor, Conrad IV., found L.33,000,000 Sterling in money; and that, as, by a religious law, every Emperor is bound to increase this treasure, during his reign, it had been vastly augmented at the time he wrote.

This accumulation of private treasure is deemed an indispensable part of the state policy of Turkey, where, as in every despotic government, the individual filling the throne is exposed to sudden insurrections and interior revolutions. Meusel thinks that this treasure was much reduced by the war with Russia, which terminated in 1812, when the private hoards were compelled to come forth in aid of the national treasury to a very great, but unknown, extent; as the army was then paid with coins of very ancient dates. The expences of the government are involved in as much obscurity as the income from which they are defrayed. The greater part of the military costs but little in time of peace; being fur-

Turkish Empire.

nished with necessaries by the several provinces in which they are quartered, and which are collected from their feudatories by the governors of them.

The debt of the state, which, in 1803, amounted to only L.3,500,000 Sterling, has been increased by the various unfortunate events that have occurred since that period to upwards of L.70,000,000; and, in spite of forced loans, to which the government has had recourse, and of large contributions from the religious establishments, the state-obligations pay an interest at the rate of 12 *per cent.*

Army and Navy.

Under a government, where all land is held on the condition of military service, the number of soldiers must be great in proportion to the population; but in Turkey the numbers have been kept down by the want of means to provide the necessary arms and equipments. According to the most recent accounts, the regular army amounts to 125,000 infantry, artillery, artificers, sappers, miners, and armourers, included; and 12,500 cavalry; but to the latter may be added 100,000 feudal horsemen, who may be made available for internal defence. The Janisaries make 80,000 of the infantry; and these are rather garrison militia, for the most part, than regular troops. The best corps consist of those called the new regulars, amounting to 24,000 men, who, as well as the artillery, are armed and disciplined after European models. The navy of Turkey has of late declined. It now consists of 15 ships of the line, the same number of frigates, and about 30 smaller vessels. Very few of these ships are fit for service; and the naval arsenal is so destitute of stores that fewer still can be equipped. At all times the best seamen in their fleet consisted of Greeks; and, since the insurrection of that nation, greater difficulties than before have been found in working and fighting their ships. This accounts for the different disasters which the Turkish navy has experienced during the course of the existing contests with their Greek subjects.

Productions of the Soil.

As the greater part of the inhabitants of the Turkish dominions are collected in and around the towns for security, the intervals of land between these towns are almost wholly uncultivated. Where any cultivation is practised, the soil is highly grateful, and produces abundant returns for the labour bestowed on it in corn, wine, oil, fruits, flax, hemp, cotton, wool, madder, and other dyeing materials. The woods afford excellent timber in abundance. Horses, cows, sheep, goats, and game, are plentifully reared. The fisheries, both in the rivers and seas, are much neglected, except by the Greeks, who have occasion for them from the numerous fasts prescribed by their religious tenets. Honey and wax are liberally supplied; and silk is collected in all the provinces south of the Danube. The mineral products are now almost wholly confined to iron, though mines of gold and silver were formerly worked in the mountains of Bosnia, and those of Moldavia and Wallachia are rich in minerals.

Manufactures.

The manufactures in Turkey are neither numerous nor abundant. The best of them is leather of various colours and qualities. Dyes of several kinds, but especially that made from madder, and universally known through Europe by the name of Turkey-red, are supplied. Cottons are made in several places, as are coarse woollen cloths and carpets. Silks and silk gauzes, of a very delicate texture, are made at Constantinople, Salonica, and at Scio. Iron, and especially steel wares, are furnished from several parts of the empire. Besides these, the smaller articles, snuff, soap, sail-cloth, glass ware, porcelain, are produced, but not in quantities equal to the demand.

Commerce.

The commerce of Turkey is almost exclusively in the hands of the Greek and Armenian subjects, or of Europeans established in the commercial cities, who are collectively distinguished by the name of Franks. The chief exports consist of cotton wool, silk, tobacco, oil, currants, rosin, wine, horses, cows, skins and hides, leather, linseed, corn, cheese, Turkish yarn, and carpets. The chief imports are—cloths of wool, silk, and cotton, colonial wares, glass, watches, hardware, paper, paints, cabinet ware, Nuremburg wares, precious stones, jewellery, and male and female slaves from Africa, from Georgia, and the Caucasian territory. The greatest traffic is with Austria, partly by land. The next in amount is with England, and then follows that with France, Italy, and Russia. The internal trade of Turkey is extensive, chiefly in the hands of Armenians, who exchange the productions of Europe for those of Asia, including India and China. Nearly the whole mercantile shipping belongs to the Greek subjects of the empire, whose resistance to its authority has an injurious effect on its general commerce. The chief trading cities in European Turkey are Constantinople, Salonica, Gallipoli, and Galatz.

The Turkish divisions of the empire are purely military, founded on feudal principles, and even retaining the military names. The whole dominion is divided into twenty-five districts, which are subdivided into sandshaks (*Standards*); each sandshak contains a number of tracts, called tiamars or siamets (*Sabres*). Besides these, there are other divisions, used purely for the civil and financial purposes of the government.

European Turkey.

The European part of Turkey comprehends the four provinces of Roumelia, Bosnia, the Islands, and the principalities of Moldavia and Wallachia.

Roumelia is subdivided into sandshaks or standards, and contains about 6,000,000 inhabitants. The most populous cities, and their estimated inhabitants, as calculated by Andreossy in the year 1815, according to the consumption of bread, were the following:

Constantinople, 597,000; Adrianople, 100,000; Salonica, 60,000; Sofia, 46,000; Ruschak, 30,000; Philopopoli, 30,000; Ionina, 30,000; Larissa, 25,000; Sistove, 21,000; Varna, 16,000; Misetra, 16,000; Scutori, 16,000; Tripoliza, 12,000; Sillistra, 10,000; and Baba, Nicopoli, Stovi, or Uskub, and Pristina, from 9000 to 10,000 each.

Bosnia contains about 850,000 inhabitants. The cities are Bosna-Serai, with 65,000; Banjaluka, with 15,000; Zwornick, with 14,000; and Trebon, with 10,000 souls.

The Ejalet Dschesair, or Province of the Islands, according to Lichtenstern, contained in 1819 about

525,000 inhabitants, chiefly Greeks, and the following cities: Galipoli, with 17,000; Castorea, with 18,000; Betaglea, with 15,000; Hydra, with 40,000; Candia, with 15,000; Negroponte, with 16,000; Canea, with 12,000; and Athens and Levadia, with 10,000 inhabitants each.

Wallachia and Moldavia are rather under the nominal than the real government of Turkey, though the Waiwode is nominated by the Porte. He is always appointed from some of the noble Greek families, generally for a short period, and uniformly by means of bribery. Wallachia contains about 1,000,000 inhabitants, chiefly of the Greek church, and they are governed by ancient feudal laws, which are corruptly administered by magistrates who owe their authority to barefaced corruption. Bucharest, the capital, contains from 50,000 to 60,000 inhabitants.

Moldavia has been contracted by cessions to Russia, and now contains about 500,000 inhabitants, who are of the same religion, and under a government similar to that of Wallachia. Jassy, the capital, contains 27,500 inhabitants. Galatz, a trading city on the Danube, has about 8000 regular inhabitants, and a vast number of strangers, who resort to it for commercial purposes.

Turkey in Asia.

Turkish Asia comprehends the following countries: 1*st*, The peninsula of Asia Minor, with the island of Cyprus, and some smaller islands in the Egean and the Mediterranean seas, and in the sea of Marmora. 2*d*, That part of Georgia which has remained to Turkey since the last peace with Russia. 3*d*, A portion of Armenia. 4*th*, The whole country of Mesopotamia, that of the Curdo, and a part of Irack. 5*th*, The whole of Soristan or Syria, with which the Turks include the district of Yemen in Arabia, over which they have no actual power, and the cities of Mecca, Medina, and Jeddo, which have been lately again taken by them from the Wahabees, but which properly form a part of Arabia. These natural or ancient divisions are now scarcely regarded by the Turks. The whole dominion is, for purposes of administration, divided into twenty-one governments, viz.

1*st*, Anatolia, including that portion of Asia Minor which comprehends the provinces of Bithynia, Paphlagonia, Galatia, Phrygia, Mysia, Lydia, Lycia, Caria, and Pisidia. The chief cities are, Kutakia, or Cotyaum, with, according to Malte-Brun, 50,000 inhabitants; Brussa, with, according to Kinneir, 50,000; Bergamo, the ancient Pergamos, Anatalia, with, according to Beaufort, 8000; Kara-hissa, with 60,000; Angora, with 20,000; Kastimuni, with 13,000; Sinope, with 10,000; Smyrna, with 100,000; Scalanuvo, with, according to Galt, 20,000; Scio, in the island of that name, with 25,000, according to Galt, 20,000; to Wittman, 25,000; and to Olivier, 30,000; almost wholly Greeks, and lately destroyed.

2*d*, Kibris, or the island of Cyprus, with about 120,000 inhabitants, of whom 16,000 are in the city of Nicosia.

3*d*, Itschill, a part of Asia Minor, comprehending the ancient Cillicia, Isauria, and Pamphylia. Its chief cities are Adana, with 30,000 inhabitants; and Tarsus, with 30,000.

4*th*, Caramania, comprehending a portion of Asia Minor, which was formerly Cappadocia, and parts of Galatia, and Phrygia Major. Its chief cities are, Konia, or Iconium, with 30,000 inhabitants; Larenda, or Caraman, with, according to Kinneir, 15,000; and Acschier, or Antioch, with 60,000.

5*th*, Merash, extending over part of Cappadocia, of Armenia Minor, and of Cillicia Campestris. The principal cities are, Merash, with 9000 or 10,000 souls; Aintab, with 20,000; and Melitene, with 8000.

6*th*, Sewas, including the greater portion of the ancient Pontus, whose principal cities are, Oskal, with 16,000 inhabitants; and Amasia, with 35,000.

7*th*, Trebisond, comprehending, to the eastern of the ancient Pontus, a portion of Armenia on the border of the Black Sea. The capital of the same name contains, according to Kinneir, 15,000 inhabitants; and Rise, or Irisch, not lately visited, but in the middle of the last century, a flourishing, manufacturing, and commercial city, has 30,000 inhabitants.

8*th*, Tschalder, or Chaldea, a part of Armenia, with which what remains to the Turks of Georgia is comprehended. The only city is Akhirssa, or Akalzike, on the great road to the passes through the mountains, which lead to the ports on the Black Sea, supposed to contain from 12,000 to 15,000 souls of all descriptions and nations.

9*th*, Kars, a part of Armenia. The chief city in lat. 40° 56′, and long. 43° 25′, of the same name, as well as the other towns, have not been recently visited, and their population is not ascertained.

10*th*, Erzerum, also a part of Armenia, supposed, by Morier, to contain from 500,000 to 600,000 inhabitants, and represented by him to be both fertile and beautiful. The capital of the same name is variously described by Tournefort, Morier, Gardanne, Kinneir, and Von Hammer; the lowest estimation making the inhabitants amount to 80,000; the highest (Morier) to 250,000. Karahissar contains 10,000, and Hamischkane 7000 souls.

11*th*, Wan, a part of Armenia and of Kurdistan. The capital, from which the province derives its name, has not been recently visited; Betlis is stated by Kinneir to contain 12,000 inhabitants.

12*th*, Schersur, a part of Kurdistan. This province is so called from its capital, in lat. 35° 46′, and long. 45° 21′, which, with all the other places, are of small consideration.

13*th*, Bagdad, a part of Mesopotamia, and the ancient Babylon, with a portion of Kurdistan. This extensive province is very thinly peopled, and recent travellers represent it as fast going to decay. Bagdad, the city which gives its name to the province, is stated by De Sacy to contain 95,000 inhabitants, or more than one-fifth of the whole population; the other towns are small.

14*th*, Basra, or Bussora, a part of Chaldea, and of Arabia. The capital of the same name contains from 45,000 to 80,000 inhabitants, according to the differing accounts of Neibuhr, De Sacy, and Von Hammer. Korna, at the junction of the Tigris with

Turkish Empire.

the Frat, is a commercial city of some importance; but its population is not ascertained.

15*th*, Mossul, a part of Mesopotamia, and of Assyria. The capital which gives its name to the province is on a fine plain, watered by the Tigris, and contains, according to Kinneir, 35,000; according to Olivier, 65,000 inhabitants.

16*th*, Diarbekr, that part of Mesopotamia which was called Bekr formerly. The capital from which the province derives its name contains, according to Kinneir, 38,000 inhabitants; but according to Gardanne, 80,000. Siwerh, a trading city on the river Frat, has a population of 10,000. The other towns are very small.

17*th*, Racca, the western part of Mesopotamia, and a part of Syria. The inhabitants live more in tents than in towns. The capital of the same name, though known in Europe more commonly by the names of Nicephorium or Kallinicum, is represented, by recent travellers, to contain from 30,000 to 40,000 inhabitants. Biredschik, a trading town on the Frat, has about 6000, and no other place more than 2000 inhabitants.

18*th*, Haleb, the northern part of ancient Syria. It is represented as a fertile, manufacturing, and commercial province, with 500,000 industrious inhabitants. Haleb, the capital, the ancient Beroe, now called Aleppo, has a population of, according to Volney, 100,000; to Setzen, 150,000; to Rosseau, 200,000; to Arvieuz, 280,000; and to Dr Russel, 235,000. It has a great trade carried on by the numerous Franks established there. Killis contains 12,000; Antokia 15,000 inhabitants. The population of Scanderoon and Latakia are not ascertained.

19*th*, Tarablus, the middle part of Syria, westward of Lebanon. The name of this province is derived from that of its capital, known to Europeans as Tripoli; which, according to Browne, contains about 16,000 souls. No other town is noticed by travellers.

20*th*, Akka, the ancient Phoenicia, and a part of Palestine. The capital of the province, Acre, or St John's d'Acre, the ancient Ptolemais, contains about 16,000 souls. The population of the other cities, except Bairut, or Beritus, which has 7000 inhabitants, is not ascertained.

21*st*, Damas, this includes the greater part of ancient Syria, extends over 26,850 square miles, and has a population of 1,250,000 souls. The province takes the name of its capital, Damas, or Damascus, which has about 200,000 inhabitants. Hamah has, according to Ali Bey, 100,000; Emessa, 30,000; Jerusalem, according to the same traveller, 30,000 to 40,000; Razza, the ancient Gaza, 5000; Ramla, or Arimathea, 10,000; and Jaffa, or Joppa, 5000 inhabitants.

Turkish Africa.

The Turkish government claims a kind of authority over some very large portions of Africa; but the local authorities can scarcely be considered as subjects of the Porte. The most important of these, Egypt, has been largely treated of in Part I. Vol. IV. of this *Supplement*. The states of Barbary, Algiers, Tunis, and Tripoli, pay, when it suits them, some tribute as acknowledgment of dependance. Nubia has been recently subjected to the Pasha of Egypt; but it is hard to define how far that country can be considered as a branch of the Turkish empire, when the conqueror of it scarcely acknowledges his dependance. The limits allotted to this article will not allow us to draw up, even in a compressed form, such particulars as have reached us respecting the northern parts of Africa; and, indeed, they more properly belong to other articles.

See *Present State of Turkey*, &c. by William Thornton, London, 1815; *Moeurs, Usages, Costumes, &c. de la Turque*, Paris, 1812, par A. L. Castellon; *Des Osmanischen Reichs Staatsverfassung und Staatsverwaltung*, von Jos von Hammer, Vienna, 1815; Clarke's, Hobhouse's, Holland's, Morier's, Kinneir's, and Wittman's *Travels*; *Karamania*, by Captain Beaufort, R. N.; Heude's *Voyage to the Persian Gulf*, 1819; Hassel's *Erdebeschreibung*, Wiemar, 1821. (W. W.)

Turkish Empire || Tyrone.

TYRONE, a county in the province of Ulster, in Ireland, having Londonderry on the north, Armagh on the east, Monaghan and Fermanagh on the south, and Donegal on the west; extends about 42 miles from north to south, 54 from east to west, and contains 1271 square miles, or 813,440 English acres. It is divided into the four baronies of Dungannon, Strabane, Omagh, and Clogher or Upper Dungannon, and 35 parishes which belong to the sees of Armagh, Derry, and Clogher. *Situation.* *Extent.*

Surface. The greater part of this district is mountainous, particularly the baronies of Strabane and Omagh on the west. In the former are two hills of great height, called Bessy Bell and Mary Gray,—names celebrated in Scottish song. Dungannon, on the east, is a rich and fertile tract, and Clogher, on the south, also contains a considerable proportion of good land; but, generally speaking, the territorial value of this inland and northern district is much inferior to that of most of the other Irish counties. Besides the usual varieties of soil, clay fit for bricks of various colours, and particularly pale bricks, which are deemed the most durable, occur in almost every parish and townland; and about Fintona, in the barony of Clogher, other sorts of clay are made into a great variety of earthenware for country use. The best pottery, perhaps, in Ireland is in the barony of Dungannon, where all sorts of coarse crockery-ware, fire-bricks, and tiles, are made of as good a quality as any that are imported. At Coal Island, in the same quarter, coal is wrought to some extent, though, according to Mr Wakefield, it is bituminous and of a bad quality. This is one of the few districts of Ireland in which there is little or no limestone. A great many small streams, having their source in the high grounds, traverse the county in every direction. The more considerable are the Blackwater, which, rising near Clogher, soon after forms the boundary on the south and south-east, till it falls into Lough Neagh, and the Mourne, which falls into the Foyle near Strabane. The Foyle also washes its north-western extremity in its course from Lifford to Londonderry, but does not properly belong to this county. Lough *Potteries.* *Rivers.*

Tyrone.

Neagh, which Tyrone touches on the east, is the largest lake in Ireland, covering, according to Wakefield, 173 square miles, or upwards of 110,000 English acres; but it is less celebrated for its scenery than some of the other Irish lakes.

Estates.

Tyrone is divided into estates of very great extent, many of them worth from L.5000 to L.7000 a-year, and its productive or arable land into very small farms, not often exceeding 20 Irish acres. The chief proprietors are the Marquis of Abercorn, Lords Belmore, Northland, and Mountjoy. The leases are for various periods,—thirty-one years and three lives, three lives, and twenty-one years and a life.

Leases.

On some estates the land passes through the hands of middlemen, in portions of various sizes, till it reaches the actual cultivator, for the most part, in very minute subdivisions. It is customary for several persons to be concerned in one townland, which is held in what is called *rundale*, the cultivated land being divided into shares, which are changed every year, and the cattle pasturing in common,—a system utterly inconsistent with profitable occupation, or the amelioration of the soil and live stock. The cattle and sheep are accordingly of a very inferior description; and the latter, which are not numerous, may frequently be seen tethered upon the small patches of herbage which are interspersed among the shares of these partnership concerns. The tillage land, too, is more frequently stirred with the spade than the plough; and where a plough is used, the team, consisting of horses, bullocks, and even milk cows, must be supplied by the contributions of three or four neighbours, who unite their means for the purpose, each attending its operation, lest his poor animal should have more than his proper share of the labour. Potatoes, oats, and flax, are the principal crops.

Towns.

The towns are Omagh, the county town, Newton-Stewart, Strabane, and Dungannon, the two latter places of considerable extent and population; besides a number of villages. Augher and Clogher, though Parliamentary boroughs before the Union, are very small places. The linen manufacture is carried on to a great extent, and the potteries and collieries before noticed also employ a considerable number of hands; to which we may add illicit distillation, which prevails throughout all the north-western counties of Ireland. The food of the lower classes is oatmeal and potatoes,—wheaten bread and butcher meat never being used but on extraordinary occasions.

Representation.

The county, which has 20,000 freeholders, sends two members to Parliament, and the borough of Dungannon a third. Before the Union, Tyrone had ten representatives in the Irish Parliament.

Population.

In 1791 the population was computed at 157,700; and by the census of 1821 it was 259,691. According to Mr Wakefield, the Catholics are to the Protestants as 6 to 1; but property is chiefly in the hands of the latter. Many of the Protestants are of the Presbyterian persuasion.

See the general works referred to under the former Irish counties, and M'Evoy's *Statistical Survey of Tyrone*.

(A.)

UNITED STATES OF NORTH AMERICA.

No single event in modern history has been of so much importance to mankind as the discovery of America. That great continent, which had been hid from the eyes of civilized nations for so many ages, comprises nearly one-third of the habitable globe. In soil and climate, it rivals the best parts of the old continent. It is not, like Asia and Africa, infested by the larger and more dangerous species of wild animals, nor deformed by vast deserts, which present insuperable obstacles to civilization. But its great and peculiar advantage lies in the unrivalled magnitude and number of its navigable rivers, which enable its most remote inland parts to hold commercial intercourse with each other, and with foreign states, with unparalleled ease and rapidity. The position of these great rivers, whose estuaries all open to the east, points out the western side of the old continent as the region with which it is destined by nature to be most closely connected. Two great classes of colonists, widely dissimilar in character and circumstances, came from Europe to occupy this new world. The Spaniards, who were first in order of time, took possession of the most populous and fertile regions; but their natural advantages were rendered abortive by political and moral evils,—a rapacious spirit, a corrupt religion, and a vicious system of government. The English, the other great class of colonists, owed their better fortunes in some measure to their apparent disadvantages. Having neither gold mines to work, nor wealthy Indians to rob, they cultivated with greater diligence the natural riches of the soil, and laid the foundation of future prosperity in habits of order and industry. Neglected by the government as a band of destitute refugees, they enjoyed what was then an unusual degree of civil and religious liberty. Their industry flourished, because it was unfettered and unburdened. They were well governed, because they were left to govern themselves. And if they wanted the aid of the mother country when that aid might sometimes have been useful, they were, on the other hand, exempted from those incessant exactions and vexations to which the Spanish colonists were exposed, from the ignorant, meddling, grasping, bigoted spirit of their European rulers. The troubles they experienced from the hostility of the Indians diminished as their own numbers increased, and, except at first, were never extremely detrimental. Their common dangers served in some measure as a bond of union among themselves, and perhaps favoured their social improvement, by acting as a slightly compressing force to prevent the indefinite diffusion of the population over a large surface. To their free spirit, virtuous habits, intelligence, and industry, the English colonists certainly owed much of their early success; but we must not forget that a series of fortunate changes, not directly the consequence of their own exertions, have greatly contributed to place them in the enviable situation they now occupy. Had the Dutch, French, Danish, and Swedish colonies planted in North America spread as fast and as far as those of England, and continued separate and independent, we should have seen, in the space between the Mississippi and the Atlantic, the same medley of nations and languages, with the same diversity of manners, religion, institutions, and clashing interests, which foster everlasting feuds and jealousies in Europe, engender desolating wars, load the people with oppressive taxes and military tyrannies, and present a formidable barrier to the circulation of knowledge and the progress of society. The conquests of England, which blended all these colonies into one nation, have secured to the United States an exemption from half the evils which afflict civil society in Europe, and prepared for them a career of peaceful grandeur and growing prosperity, which divided Europe cannot hope to enjoy, and which has had no parallel in the history of mankind. The people of the United States find themselves in a condition to devote their whole energies to the cultivation of their vast natural resources, undistracted by wars, unburdened by oppressive taxes, unfettered by old prejudices and corruptions. Enjoying the united advantages of an infant and a mature society, they are able to apply the highly refined science and art of Europe to the improvement of the virgin soil and unoccupied natural riches of America. They start unincumbered by a thousand evils, political and moral, which weigh down the energies of the old world. The volume of our history lies before them: they may adopt our improvements, avoid our errors, take warning from our sufferings, and with the combined lights of our experience and their own, build up a more perfect form of society. Even already, they have given some momentous and some salutary truths to the world. It is their rapid growth which has first developed the astonishing results of the productive powers of population. We can now calculate with considerable certainty, that America, which yet presents to the eye, generally, the aspect of an untrodden forest, will, in the short space of one century, surpass Europe in the number of its inhabitants. We even hazard little in predicting, that, before the tide of civilization has rolled back to its original seats, Assyria, Persia, and Palestine, an intelligent population of two or three hundred millions will have overspread the new world, and extended the empire of knowledge and the arts from Cape Horn to Alayska. Among this vast mass of civilized men, there will be but two languages spoken. The effect of this single circumstance in accelerating the progress of society can scarcely be calculated. What a field will then be opened to the man of science, the artist, the popular writer, who addresses a hundred millions of educated persons?—what a stimulus given to mental energy and social improvement, when every new idea, and every useful dis-

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covery, will be communicated instantaneously to so great a mass of intelligent beings, by the electric agency of the post and the press? With the united intellect and resources of a society framed on such a gigantic scale, what mighty designs will then be practicable? Imagination is lost in attempting to estimate the effects of such accumulated means and powers. One result, however, may be anticipated. America must then become the centre of knowledge, civilization, and power; and the present leading states of Europe (Russia perhaps excepted), placed on the arena amidst such colossal associates as the American Republics, will sink to a subordinate rank, and cease to exert any greater influence on the fate of the world than the Swiss Cantons do at the present day.

Extent and Limits.

The territory of the United States is situated between the 25th and 49th degrees of north latitude, and between the 67th and 124th degrees of west longitude from London. Its extreme length east and west is 2780 miles, its greatest breadth north and south 1230 miles, and its area, according to Mr Mellish, 2,076,410 square English miles. It is bounded on the east by the Atlantic Ocean, on the north by the British possessions, on the west by the Pacific Ocean, and on the south by Mexico and the Mexican Gulf. The Mississippi divides it into two parts nearly equal in extent. In the north-east angle of this territory, there is a space of more than 100 miles square, of very barren ground, interposed between New Brunswick and Lower Canada, the possession of which has long been the subject of negotiation between the British and American Governments. On the west coast the Americans have an unquestioned claim to the country, between the 42d and 47th parallels; but Russia disputes the right of possession with them to the tract of country between the 49th and 60th parallel. As the admitted boundaries are in general very distinctly marked on the common maps, we shall not describe them in detail.

Natural Divisions.

Two chains of mountains separate this extensive territory into three great natural divisions. 1. The Atlantic region, or the country lying east of the Alleghany mountains. 2. The valley of the Mississippi, or the country watered by the Mississippi, Missouri, and their numerous branches. 3. The Pacific region, or the country lying west of the Rocky mountains.

The Alleghany mountains commence in Lower Canada, below Quebec, and passing along the northern boundary of Maine, and through New Hampshire, Vermont, New York, Pennsylvania, Virginia, and the two Carolinas, they terminate in the upper parts of Georgia and Alabama, preserving a south-west direction throughout. They consist of three, four, five, or more distinct ridges, with wide and fertile vallies interposed. Their entire length is 1100 miles, their breadth varies from 110 to 150. In the northern half their height is greatest, but most unequal, detached peaks are numerous, and the ridges indistinctly marked. In the south, the ridges are lower, but better defined, and their summits are often distinguished by a very uniform continuous level. They attain their greatest height in New Hampshire, where Mount Washington has an elevation of 6600 feet. Their greatest height in New York is 3800, in Pennsylvania 2500, in Virginia 3900, in South Carolina 4000. The mean height is said by Mr Mellish to be from 1000 to 1800 feet, but his average is undoubtedly formed on wrong principles. That of the highest chain cannot be less than from 2000 to 2500 feet.*

The Rocky mountains, known but imperfectly, are a continuation of the Mexican Cordilleras, and extend to the Polar Ocean. They pass through the territory of the United States, at the distance of 500 miles from the Pacific Ocean, and consist of several elevated chains, occupying a breadth of 300 miles, with deep vallies between them. They rise abruptly from their base, and are supposed to reach the elevation of 12,000 feet in their highest summits, many of which are covered with perpetual snow. There are, however, several passes through them, which, with a little improvement, might be traversed by loaded waggons.†

Atlantic Region.

The *Atlantic Region* was the first settled, and is the most populous and improved portion of the United States, but not the most favoured as to soil and climate. It may be considered as the eastern slope of the Alleghanies. Including all the countries watered by rivers flowing into the Atlantic and the Gulf of Mexico, east of the Mississippi, it is about 1700 miles in length, with an average breadth of 250, and embraces an area of 400,000 square miles. It includes three well marked varieties of soil and surface. 1. The alluvial district, consisting of sand, gravel, and clay, comprising a stripe of level land, extending along the coast from New York southward, with a breadth varying from 20 miles to 100. The surface is level or slightly undulating; and it embraces large tracts of marsh near the coast. The soil is poor and sandy, producing almost nothing but pines, except in the alluvial tracts which skirt the rivers. About one-half of the surface of New Jersey, Delaware, and Maryland, one-fifth of Virginia, one-third of the Carolinas, Georgia, Florida, and Alabama, fall under this description. 2. The upland country, extending from the alluvial tract to the foot of the mountains, with a breadth varying from 20 to 200 miles. The soil here is chiefly formed from the detritus of the primitive rocks, and is generally fertile, and well adapted for tillage. 3. The ridges of the Alleghanies, and the vallies between them, which bear a strong growth of natural wood, have generally a rich soil capable of tillage, wherever the surface is not rocky or too steep; and are almost free from marshes. In part of Pennsylvania, New York, and in

* Mellish's *Geographical Description of United States*, Philadelphia, 1822, p. 20. Warden's *Statistical, Political, and Historical Account of United States*, 1819. Introduction.

† Mellish, p. 21. James's *Account of an Expedition from Pittsburg to the Rocky Mountains in* 1819, 1820, Vol. III. p. 238. Warden, III. 161.

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the six New England States,* where the Alleghanies spread out into an irregular broken surface, the soil possesses a mixed character. The northern parts of New England are mountainous, the southern hilly or uneven. The soil, comparatively speaking, is rocky, has little depth, and is better adapted for pasture than tillage, and improves generally as we advance inwards from the coast. The south-east section of New York corresponds in character with New England. But Pennsylvania contains the largest portion of good soil on the east side of the mountains, of all the old States. The woods originally covered all this Atlantic region, except some tracts called by the Americans *prairies*, on which, from causes not well explained, no natural growth of timber exists. These are not meadows or wet grounds, as the French term might be supposed to indicate; but lands bare of wood, whether wet or dry, level or uneven. As the population thickens, the forests disappear; but even in the most densely peopled parts, the woodlands occupy so large a proportion of the surface, that the country generally presents, to the eye of a European, the aspect of a natural wilderness, but broken by patches of cultivation, which are numerous round the great cities, but grow less frequent as we recede from the shore, till they terminate in the boundless forests of the Alleghanies.

Valley of Mississippi.

The basin or *Valley of the Mississippi*, which extends from the Alleghanies to the Rocky mountains, is not so large as the basin of the Amazon by one-third, but being situated in the best part of the temperate zone, it may be pronounced the finest valley in the world. Its breadth east and west is 1400 miles; its length in the opposite direction 1200, and its area 1,400,000 square miles. It comprehends a great diversity of soil, surface, and climate. 1. The basin of the Ohio, including the Cumberland, 700 miles long and 300 broad, is a rich and beautiful country; the garden of the United States. The lower parts of the surface are from 500 to 800 feet above the level of the sea, and are finely diversified with round topped arable hills, rising 400 or 500 feet above their base. The rivers generally run in deep hollows, sometimes mere ravines, but often spreading out into vallies, which include lands of exuberant fertility. This district includes Kentucky, Tennessee, with part of Virginia, Pennsylvania, Ohio, Indiana, and Illinois. 2. The territory extending from the basin of the Ohio north-westward to Lake Superior, including the country between the Missouri and Upper Mississippi. The surface is sometimes undulating, sometimes so level that the waters stagnate on it, till carried off by evaporation; and it is not broken by any notable elevations, except one long ridge extending between the Missouri and Mississippi, and two low eminences called the Ocooch and Smoky mountains. The soil is naturally rich, and covered with luxuriant herbage; but the climate is severe, and the woods so thin, that the bare ground or prairies occupy three-fourths of the surface on the east side of the Mississippi, and nineteen-twentieths on the west. The absolute elevation of the northern parts is probably not under 1500 feet, for Cassina lake, 30 miles below the sources of the Mississippi, is 1330 feet above the sea. (Mellish, p. 32. James's *Expedition*, III. 204.) 3. The last and largest division of this great valley, extending from the Mississippi and Missouri to the Rocky mountains, consists of two very different qualities of soil, which graduate into each other, but, on the great scale, may be conceived to form two parallel tracts of nearly equal extent, parted by the 98th meridian. In the middle of the eastern section, and, as it were, in the very bottom of the great basin of the Mississippi, lie the Ozark mountains, a chain like the Alleghanies, of great length and breadth and small height, rising only from 1000 to 2000 feet above the sea. (James's *Expedition*, III. p. 313.) Mr Mellish erroneously calls the height 3500 feet. Their breadth is from 100 to 150 miles: their sides, which slope with gentle declivities, are deeply furrowed with streams, and partly covered with small timber. The Arkansas and Red River are the only streams which cut their way through this chain. On the east side of the Ozark chain is the Great Swamp, 200 miles long and 20 broad, which is converted into a lake by the annual overflow of the Mississippi, but is dry during the heats of summer, and rendered impenetrable at all times by a thick growth of cypress. The country round it is rich bottom or meadow land, clothed with excellent timber. The country for one or two hundred miles west of the Ozarks is also good, but less wooded; and in the eastern section, taken altogether, the open ground occupies nineteen-twentieths of the surface. The western section, extending from the meridian of 98° to the Rocky mountains, is comparatively dry and sterile, and much of it an absolute desert, destitute of herbage, and unfit for human habitation. As we approach the mountains, the ground, which is at first hilly, subsides into smaller undulations, and these terminate in table lands, nearly flat on the top, with steep, and sometimes precipitous sides, and rising 600 or 800 feet above the common level. These table lands, consisting of alternate beds of sandstone and breccia, increase in number and diminish in extent, as we approach the base of the mountains, which is believed to have an elevation of 3000 feet above the sea. The desert aspect of the country, however, is not the effect of its elevation, but more probably of its aridity; for vallies among the mountains, which are still higher, are fertile. The rivers in this frightful solitude often spread out to a breadth of one or two miles, and dry up in the warm weather. Salt springs are numerous, and salt incrustations cover many square miles. Trees are only to be seen at some spots along the rivers, and are rather more abundant in the south than in the

* As the name of New England occurs often in American books, it may be proper to mention, that the appellation is applied to the six States east of the Hudson,—Connecticut, Rhode Island, Massachusetts, Vermont, New Hampshire, and Maine.

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north; but throughout the whole section, the wood does not cover the thousandth part of the surface. Of the basin of the Mississippi altogether, it may be observed, that the western side is a barren desert; the middle contains much good lands, but abounds in swamps; the east side, comprehending the basin of the Ohio, is the richest, and the most eligible for human habitation. The woods, in their natural state, increase continually as we advance from the Rocky mountains to the Atlantic, a proof, perhaps, that the summer heat, and the quantity of atmospheric moisture, follow a similar law.*

Pacific Region.

The *Pacific Region* extends from the Rocky mountains to the ocean, and (exclusive of disputed ground) from latitude 42° to 49°, embracing an area of 300,000 square miles. It consists almost entirely of the basin of the Columbia river. A chain of mountains runs through it from south to north, about 150 miles from the coast, between which and the Rocky mountains there is a high valley, 300 miles broad, intersected by smaller chains, but well wooded and watered, and enjoying a pure air and a fruitful soil. The land between the outer chain and the coast is nearly of the same description, but much lower, and overcharged with moisture from frequent and heavy rains. The climate is remarkably mild and equable, resembling that of France and Spain much more than that of the Atlantic coast. Frost is rarely seen in winter at the mouth of Columbia river, though it is in the same latitude as Quebec, where the ice lasts five or six months.†

Climate.

The United States, whose territories almost touch the tropic on the one side, and reach to districts where frost lasts five or six months on the other, embrace greater varieties of climate than any other single state in the world. Generally speaking, the climate of the United States is distinguished from that of Europe by three peculiarities. 1. It is absolutely colder for the corresponding degrees of latitude, the mean temperature of the year, according to Humboldt, being nine degrees of Fahrenheit lower on the east coast of America than on the west coast of Europe at the latitude of 40°, and 12½° lower at the latitude of 50°. 2. The thermometer has a greater range, as the heat of summer and the cold of winter reach greater extremes. 3. The climate changes more rapidly as we proceed from south to north, or a greater variety of climates is comprised within the same range of latitude. The mean temperature of Quebec, at one extremity, is 42°, and of Cape Sable, at the other, 72.7°. Between the parallels of 38 and 50, a degree of latitude which make a change of 1.13° (Fahrenheit) in Europe, makes a change of 1.57° in the United States; and the same annual temperature which is found at a given degree of latitude in the United States, is found seven degrees farther north in Europe. The seasons are also very differently distributed. Philadelphia, for instance, has the summers of Rome and the winters of Vienna. In Florida, at New Orleans, and at St Mary's in Georgia, snow is never seen; but in Pennsylvania snow lasts three months, in Massachusetts four, and in Maine five.‡ In the two latter states, the ice bears loaded waggons, and the sea is sometimes frozen to a considerable distance from the coast. In all the low country, from Florida to the St Lawrence, the extreme summer heat is nearly the same, from 90° to 98°, and the varieties of climate are marked chiefly by the intensity and duration of the winter's cold. The climate in the basin of the Ohio, compared with that of the Atlantic coast, possesses no very striking peculiarities, but seems, on the whole, to have its mean annual heat a little higher, to be rather more steady and equable, to be less frequently visited by the frigorific north-west winds, and to have fits of cold weather almost equally severe, but more transitory. The great lakes appear to mitigate the winter cold in the country immediately around them, and probably in the basin of the Ohio too, for on the west and north-west of this district the climate is much more rigorous. At Council Bluffs, on the Missouri, in latitude 41½°, the thermometer descends to —22° in winter, and rises to 105° in summer. At St Peter's Fort, on the Mississippi, in latitude 45°, it ranges from 92° to —30°, and the mean temperature of January is about *Zero*. The absolute height of the fort, which cannot exceed 1000 feet, does not account for this excessive cold. We have already mentioned the equable temperature of the basin of the Columbia; and, from the observations made on the Missouri and Upper Mississippi, we have reason to believe that the mildest and the most rigorous winters known in any similar latitude are to be found at once on the opposite sides of the great rampart of the Rocky mountains. (On the subject of Climate, see Mellish, p. 59—77.)

Rain and Winds.

So many local circumstances affect the annual depth of rain, that little confidence can be put in general estimates. We find that it was 42 inches at Charlestown, on an average of some years, 40 at Natchez, 30 at Philadelphia, 36 at Cincinnati. The mean fall of rain for the inhabited part of the United States (latitude 41°) should be about 34 inches. (See the Article PHYSICAL GEOGRAPHY.) The frequent failure of the streams, and the scarcity of verdure in the country near the Rocky mountains, indicates a deficiency of atmospheric moisture in that region. Snow falls to the greatest depth on the borders of the great lakes. On the sea coast it is rarely seen farther south than Northfolk, latitude 37°; but in the interior, it is found four or five degrees farther south. Compared with the middle countries of Europe, the United States, occupying a more southern position, have rains more regular and heavy,

* This account of the basin of the Mississippi is entirely taken from Major Long's *Memoir*, published in the third volume of James's *Account of the Expedition to the Rocky Mountains*.

† Morse's *American Universal Geography*, 7th edition, 1819, Vol. I. p. 671. Mellish, p. 417.

‡ Humboldt, *Prolegomena de Distrib. Geog. Plant.* 1817, p. 68—71. Warden, Vol. I. p. 287, 353. Vol. II. p. 60.

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and greater in absolute quantity, but a smaller number of wet days. Of the winds, the most remarkable are, 1. A moist and warm south or south-west wind, which is supposed to be a branch of the trade-wind, and is felt all over the Atlantic States as far as the Potowmac, and occasionally in New England. 2. Another wind, possessing the same qualities, and believed also to be a branch of the trade-wind; it blows from the Mexican Gulf up the course of the Mississippi, and seems to send off subordinate branches, which ascend the courses of the Ohio and Missouri. In Louisiana and Arkansas, it is a south wind; at Council Bluffs, on Missouri, it is a south-east; and in Ohio and Kentucky, a south-west wind. It is the prevailing wind in all these districts. 3. The north-west blows occasionally on the west side of the Alleghanies, but more frequently on the east side, and is most prevalent in New England. It everywhere produces intense cold, depressing the thermometer to —7° or —8° in Ohio, and sometimes to —20° in Massachusetts. 4. The north-east is a cold wind, which, transporting the fogs of the Newfoundland bank, occasions showers of snow. Various facts observed in the United States seem to show, what some meteorologists have doubted, that clearing and cultivation improve the climate, at least so far as regards the growth of the cerealia.*

Geology.

If we draw a line from New York to the east end of Lake Ontario, the peninsula lying north-eastward between the St Lawrence and the sea consists of primitive rocks, interspersed with some patches of secondary. From this line southward, the country has a different geological character. A belt of alluvial soil, beginning at Long Island, extends along the shore of all the southern states to Natchez on the Mississippi, having an average breadth of a hundred miles, and including, probably, all Florida, except some high ground in the interior. It is everywhere penetrated by the tide water in the rivers. On the west side of this is a region of primitive rocks, from 100 to 200 miles broad, in which gneiss predominates. It embraces the eastern ridges of the Alleghanies, with the rolling country at their foot. On the west side of this, again, is a long narrow zone of transition rocks, including the western ridges of the Alleghanies, and extending from Lake Champlain to the north-west angle of Georgia. From this transition formation, which forms, as it were, the eastern edge of the basin of the Mississippi, immense beds of secondary limestone, sandstone, and shale, cover the country to the Rocky mountains, interrupted only by the alluvial formations on the banks of the rivers, and by the Ozark mountains. These mountains are formed, like the Alleghanies, of the same formations, disposed in the same order. The Rocky mountains, so far as they have been explored, consist of primitive rocks, granite, gneiss, quartz rock, &c., covered on the east side by an extensive formation of old red sandstone. †

Minerals.

That important mineral, coal, is found on both sides of the Alleghanies. The two principal formations on the east side are, 1. On the river Apomatox, above Richmond (Virginia), where a seam of excellent coal, which occupies a basin 20 miles long and 10 broad, has been long worked, and employs 5000 persons; 2. At various spots along a narrow tract of country, from the sources of the Juniata and western Susquehannah to Providence Bay. At Lehigh, and other parts within this district, the coal is worked. On the western side of the Alleghanies, an immense formation of coal, probably the largest in the world, extends from the head waters of the Ohio southward to those of the Tombigbee, and westward, with some interruptions, beyond the Mississippi. A similar bed appears on the west side of the Ozarks, which is also traced far up the course of the Missouri; and there is a third bed, of unknown extent, on the east side of the Rocky mountains. ‡

Salt, another mineral of primary importance, is distributed in considerable abundance over the United States territory, especially those parts that are remote from the sea. A great formation of rock salt (and gypsum), indicated by numerous salt springs, is believed to accompany the coal formation over a great part of the basin of the Mississippi. Salt springs are numerous at the foot of the Rocky mountains, and extensive plains occur covered with salt, one of which, the Grand Saline, is 30 miles in circumference, and in hot weather is covered with a crust of clear white salt, from two to six inches deep, and superior in quality to manufactured salt. On the east side of the Alleghanies, salt is generally obtained from the ocean, or imported.

Iron is found in nearly all the States, and is worked to such an extent, that of 50,000 tons consumed, according to computation, in the country, only 10,000 are imported. (Morse, I. 236.) A bed of magnetic iron ore, from eight to twelve feet thick in gneiss, and another from two to twenty feet, extend, with some interruptions, from the White mountains, on the one side, and from Lake Champlain, on the other, to the northern limits of New Jersey. Iron ore, of various kinds, is also met with in Maryland and Virginia. On the west side of the Alleghanies it is abundant, and is extensively worked at Pittsburgh, and in Kentucky and Tennessee. The whole number of furnaces, forges, and bloomeries, in 1810, was 530. Ores of copper are smelted in New Jersey, and are found in various other parts of the Union. Native copper is said to exist in great quantities near the river St Croix, in the north-west territory; but at present, the United States are supplied with this metal chiefly from Mexico. Lead is

* Warden, Vol. I. p. 289, 355. Birkbeck's *Letters from Illinois*, p. 37.

† Maclure's *Observations on the Geology of United States, passim.* Major Long's *Memoir*; and Engraved Sections in James's *Expedition*.

‡ James's *Expedition*, Vol. III. p. 96, 298, and Engraved Sections. Maclure, p. 35. Warden, Introduction, p. 32.

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found in Massachusetts and Pennsylvania, but it exists most abundantly in Missouri, at the north-east angle of the Ozark mountains, where 45 mines are worked, which yield three millions of pounds annually. (Mellish, 366.) Gold and silver are met with, but only in minute quantities. Mercury and tin have not been found. Cobalt, antimony, manganese, and ores of zinc, occur in some few spots. Nitre is obtained in vast quantities from the limestone caves in Kentucky. On a general view, it may be said that the United States, so far as explored, are nearly destitute of the precious metals, but have a supply of coal, salt, iron, lead, and probably copper, adequate to their own consumption.

Lakes.

The United States have no considerable lake, entirely within their territory, except Michigan. But a series of fresh water lakes, by far the largest in the world (for the Caspian Sea is salt), and connected with one another by the St Lawrence, extend along their northern frontier. The following is their extent, and their elevation above the level of the sea:

Lakes.	Length.	Breadth.	Area.	Height in Feet.
Superior,.......	350	150	35,000	642
Huron,..........	220	150	17,000	589
Michigan, ...	310	70	18,000	—
St Clair,.........	30	30	900	570
Erie, ...	230	55	10,300	560
Ontario,.........	170	50	7,200	110
			88,400	

Reckoning from Quebec to the western extremity of Superior, these lakes afford a line of 1550 miles of inland navigation, which will be increased to 4500 miles if we include the whole extent of their shores. But Quebec is far from the open sea, and the shortest and best route to the Atlantic from Lake Erie and the waters above will be by the New York canal. Lake Erie is about twenty fathoms in average depth, Ontario eighty, and Lakes Huron, Michigan, and Superior, are said to be still deeper. All these inland waters can be navigated with advantage; and will be crowded with vessels at some future period, when an active population covers the north-west territory. The principal interruptions at present are, 1st, At the rapids between Montreal and Kingston, where it is proposed to cut a canal. 2d, At the rapids and the great fall of Niagara, where a canal is also projected. 3d, In the stream of the river between Lakes Huron and Erie, where there are also rapids, and in Lake St Clair, which is full of shallows. 4th, At the falls of St Mary, between Huron and Superior, amounting to twenty-three feet in half a mile. All these obstructions, it is believed, can be surmounted by art. These various lakes evidently occupy the bottom of a raised plateau, the outer sides of which are not very distant; and hence they receive very few rivers of any magnitude. Their shores are beset with ice for two, three, or four months in the year.

Lake George, 36 miles long and 7 broad, pours its waters into Lake Champlain, which is 160 miles long and 18 broad, and communicates by the River Sorelle with the St Lawrence. A canal, 22 miles long, now nearly finished, connects Lake Champlain with the Hudson. We pass over the other lakes of smaller size.

Rivers.

The rivers of the United States belong to four different systems; 1st, Those which water the Atlantic region. 2d, The Mississippi and its branches, which water the great central valley of North America. 3d, Those which flow into the St Lawrence; and, 4th, The Columbia and its tributaries, which flow into the Pacific Ocean.

Eastern Rivers.

The rivers which fall into the Atlantic, and the Gulf of Mexico, from Maine to the eastern boundary of Louisiana, all rise in the Alleghanies, except the Susquehannah and the Hudson, which pass entirely through the principal chains. Their length varies from 200 to 450 miles, increasing gradually with the breadth of the level country, as we advance southward. The tide-water ascends in all these rivers to the outer boundary of the primitive formations, where falls regularly occur, except on the Hudson. In this river, the tide reaches to Albany, 160 miles from its mouth, to which point there is an uninterrupted navigation for sloops of 80 tons. This peculiar advantage has made the Hudson the scene of a more active inland trade than any river, perhaps, in the world, of the same magnitude. Tide navigation reaches a very short way up the great rivers in the northern states generally; but in those south of the Susquehannah, it reaches generally from 100 to 130 miles. Boats ply on these rivers much farther up, but the navigation is seldom uninterrupted. The following are the principal rivers on the Atlantic side, with their approximate lengths.

	Miles.		Miles.
Connecticut,...	290	Roanoke,..............	230
Hudson,..............	300	Pedee,................	290
Delaware,...........	270	Santee,...............	300
Susquehannah,......	350	Savannah,...........	280
Potowmac, ...	260	Catahouche,.........	400
James' River,........	200	Alabama,.............	440

Northern Rivers

The rivers that fall into the St Lawrence, and its lakes, are comparatively small, and probably do not carry off one-tenth part of the water that falls on the east side of the Mississippi. The most considerable are the Fox River, which falls into Lake Michigan, the Miamie of Lake Erie, the Genessee, and Seneca of Lake Ontario, and the Saurelle or Richlieu, which joins the St Lawrence below Montreal.

Mississippi.

The majestic Mississippi drains a greater surface than any river in the world, except the Amazon, and in the magnitude of its stream is only surpassed by the Amazon and the Plata. It has been computed to convey to the Mexican Gulf $\frac{1}{38}$ of all the water which the ocean receives from the dry land. (See Physical Geography.) The extreme length of the Mississippi Proper, including all its sinuosities, is generally computed to be 2500 miles, but reckoning to the head of the Missouri, which is the largest branch, it is nearly 4000. It has three bars at its mouth, the deepest of which affords only 17 feet of water. (Warden, I. 114.)

Sloops of this draught can navigate to Natchez, 350 miles from its mouth. There is depth sufficient at all times for sloops drawing six feet to the Ohio, and for vessels drawing three feet to the junction with the Missouri. (James's *Expedition*, III. 258.) But, during the floods in May, June, and July, the waters rise 50 feet, and are then navigable by vessels of any size. The Mississippi, from its junction with the Ohio to the sea, is about 1000 yards, or two-thirds of a mile in width, and below Red River it is about 120 feet deep. From the junction of the Arkansas, its banks form an elevated ridge or platform, which support the stream at the height of ten or twenty feet above the level of the adjacent lands. In its floods, it sometimes bursts the barriers which confine it, and inundates the flat country below. Of the two great branches, the Missouri, and Mississippi Proper, the former stream is the larger, and more rapid, and also more turbid, from the quantity of travelled soil it transports. But its waters, generally occupying a wider channel, are more loaded with bars and sandbanks, and the navigation is more intricate. (James's *Expedition*, III. 259.) The Platte, Kansas, and some other tributaries of the Missouri, often spread out to a breadth of one or two miles, and during the warm season, dry up entirely. But these, and all the branches of both rivers, generally admit of boat navigation for nine-tenths of their course, during a longer or shorter period every year. In the Ohio, the boating season is from 20th February to the middle of June. Before this period the waters are ice-bound; after it, they are too shallow, except for very small craft. The length of the Mississippi, from its mouth to the junction of the Ohio, is about 1200 miles, and to its junction with the Missouri, 1300. The length of the Missouri, above the junction to its remotest branch, is, by Lewis' and Clarke's measurement, 2575 miles. The length of the Ohio, above the point of confluence, is 1188 miles. The other large branches of the Mississippi are the Red River and Arkansas, in the lower part of its course. The chief tributaries of the Missouri are the Osage, Platte, Kansas, and Yellowstone; of the Ohio, the Tennessee, Cumberland, and Wabash. The whole extent of the navigable waters above the confluence of the Missouri and Mississippi has been estimated at 23,000 miles, to which, if we add 12,000 for the Ohio, Arkansas, Red River, &c. and their branches, we shall have 35,000 miles of boat navigation in the basin of the Mississippi. To this we may add 10,000 miles more for the eastern section of the States, with 5000 for the lakes and their tributary streams, and 2000 for the River Columbia, making altogether 51,000 miles of river navigation, which is probably three times greater than all the rivers of Europe afford. Except in New England, Pennsylvania, and New York, the rivers of the United States flow over a surface which has rather a small declivity. Of the two sides of the great central valley, the western in the steepest. The base of the Rocky mountains is computed to have an elevation of 3000 feet. That of the beds of the rivers, where they begin to be navigable, may be about 2000; and estimating their average length of course to the sea to be about 2500 miles, the mean fall will be about nine or ten inches *per* mile. The Mississippi Proper, at 2500 miles from the sea, has a height of 1330 feet, or a mean fall of six or seven inches *per* mile. The Ohio, at Pittsburgh, 2200 miles from the sea, has a height of 600 feet, or a mean fall of four inches. In the Amazon and the Ganges, from the point where they leave the mountains, and in the Wolga, from its source, the average rate of descent is from four to five inches *per* mile. In the middle and south of Europe, generally, the fall of the rivers is probably twice as great. *

Cultivated Plants.

The variety of cultivated plants in North America corresponds to the diversity of its climates. At one extremity, the sugar cane of the tropical regions thrives, and at the other, oats and barley, the staple crops of the Arctic regions, are leading articles of cultivation. The high summer heat, however, in all parts of the United States, makes some plants, which cannot be raised in England, succeed in the coldest districts of the north. Of this description is maize, or Indian corn, an indigenous American plant, which is cultivated from Maine to Louisiana. It is a vegetable in universal use in the United States, yields generally double the produce of wheat, and is adapted to a greater variety of situations. The maple tree, which grows in all the States, yields a juice from which sugar is made. Nearly ten millions of pounds of maple sugar were made in 1810. Wheat is raised from one extremity of the Union to the other, but succeeds best in the middle and western States, and in the uplands of the southern. The cultivation of tobacco begins in Maryland, about the parallel of 39° or 40°, and continues through all the southern States, and through those in the west, south of the Ohio. The climate favourable for cotton is not found farther north than about the latitude of 37°, though it can be raised as far north as 39° on both sides of the mountains. The best grows in South Carolina and Georgia, in dry situations upon the sea coast. The rice crops, which require a marshy soil, and a great heat, commence about the same parallel with cotton, and have nearly the same geographical range. The sugar cane grows in low and warm situations, as high as the latitude of 33°, but the climate favourable for its cultivation does not extend beyond 31½°. Oats, barley, hemp, and flax, succeed well, except in the low grounds of the southern States. The vine can be advantageously raised as far north as Pennsylvania. The olive, orange, lemon, and fig, are injured by the frost in South Carolina, but it is believed, that these trees, as well as the banana, will succeed in Florida.† The forest trees of the United States com-

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* Physical Geog. in this *Supplement*. Warden, I. 115. Mellish, 32. Major Long's *Memoir* in James's *Expedition*, with the Sectional Maps.

† Warden's Introduction, 27. II. 399. III. 222. Humboldt, *Proleg*. 156.

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Animals.

prise almost all the valuable and useful species of wood.

The United States contain about one-fourth of the known species of quadrupeds. Some are common to both continents, others are peculiar to the western. Comparing individuals of the same species, some are perfectly similar; between others there is some difference in size, colour, or other circumstances. In a few instances, the animal of the eastern continent is larger than the American; in most the reverse is the case. The following is a catalogue of the quadrupeds of the United States.

Mammoth (an extinct species),	Lynx,	Flying Squirrel,
Bison or Buffalo,	Kincagou,	Field Mouse,
Moose Deer,	Weasel,	—— Bat,
Caribou,	Ermine,	Ground Mouse,
Red Deer,	Martin,	Wood Cat,
Fallow Deer,	Mink,	American Rat,
Roe,	Otter,	Shrew Mouse,
Bear,	Fisher,	Purple Mole,
Wolverene,	Skunk,	Black Mole,
Wolf,	Opossum,	Water Rat,
Fox,	Wood-Chuck,	Beaver,
Catamount,	Urchin,	Musquash,
Spotted Tiger,	Hare,	Morse,
Sallow Cougar,	Racoon,	Seal,
Gray Cougar,	Fox Squirrel,	Manati,
Mountain Cat,	Gray Squirrel,	Sapajou,
	Red Squirrel,	Sagoin.

Nine-tenths of these animals yield a fur, which is used for dress or in manufactures. The bison, or wild ox (improperly called the buffalo), is, according to some American naturalists, of the same species with the common neat cattle of the United States, the difference being the effect of the domestication of the latter. Buffon, however, thinks otherwise. The bison is larger than the domestic ox, has a fleshy or grisly substance extending along his shoulders and back, and has on his neck and shoulders a woolly hair, which admits of being spun or wrought into hats. The moose-deer, now rare, is a gigantic animal, one variety sometimes reaching the height of 12 feet. The caribou is probably the reindeer of Scandinavia. The bear is of two species. The short-legged lives chiefly on vegetable food, and is probably not carnivorous. He dozes away the winter in a torpid state, sucking his paws, and expending the fat he had previously acquired. The ranging bear is larger, but more lean. He destroys calves, sheep, pigs, and sometimes children, and in winter migrates southward. The wolf, like the bear, is found in all the States. It is a voracious animal, stealing into sheepfolds at night, attacking deer, hogs, and small cattle, and sometimes hunting in packs. The catamount is of the size of a large dog, and extremely ferocious, but it is rarely seen. The spotted tiger is scarcely seen, except near Louisiana. It is from five to six feet long. The cougar or American panther is about the same size, but more common. It destroys sheep, calves, and hogs, and, when hungry, will attack large cattle. The urchin differs in several respects from the European hedgehog. The lion, leopard, striped or true tiger, hyena, elephant, rhinoceros, hippopotamus, camelopard, are unknown in the New World. The horse, the ass, the sheep, the goat, the hog, and the camel, did not originally exist there, but have been naturalized. The latter, however, are not numerous, and have never been introduced into the United States. Of the birds and reptiles our limits will not allow us to speak in detail. The eagle, pheasant, grouse, partridge, swan, Canadian goose, ptarmigan, are less or more numerous. In general, the small birds of America surpass those of Europe in the beauty of their plumage; but are much inferior to them in the melody of their notes. Among the reptiles, the most remarkable is the alligator or American crocodile, from 12 to 23 feet long, very strong and active. Of serpents, the rattlesnake, from four to six feet long, is the most formidable.*

Population.

Perhaps no single circumstance connected with the United States has attracted so much attention as the rapid growth of their population. Philosophers had shown, from the laws which govern propagation, that the human species might double its numbers in a short period. But this was only known as a speculative truth, applicable, it was supposed, to small tribes under extraordinary circumstances, but not to a great nation of many millions. The Spanish colonies, planted a hundred years earlier than the United States, should have made this principle familiar to the world long ago, but ignorance and misgovernment, intercepting the bounty of nature, inflicted all the vices and evils of old societies upon these colonies, and a jealous policy threw a veil of secrecy over their condition.

The first European emigrants settled in the United States in 1607. From that period, colonists continued to flock to the country in small parties or large bodies. The last new settlement on a considerable scale was in 1733, when, by means of a grant of L. 10,000 from Parliament, and various sums raised by private contributions, 618 persons were sent out from England to Georgia.† The growth of the colonies was rapid and obvious; but much more of it was probably attributed to the influx of settlers from the mother country than was consistent with the truth. No accurate enumeration of the inhabitants was made till the first census was taken in 1790. That for the year 1753, in Marshall's *Life of Washington,* is undoubtedly erroneous. The ratio of increase being ascertained by the four separate enumerations, and having continued remarkably uniform for forty years, we can now, by calculating backwards, obtain results more deserving of confidence than the rude guesses made from uncertain

* Morse, Vol. I. p. 263, &c. Warden, Chap. 6. Buffon's *Quadrupeds,* Vol. II. London edit. 1775.

† For an account of this and the earlier settlements, the reader may consult the *History of the British Empire in America,* 2 vols. 8vo, Lond. 1741.

data. The period of doubling at present is $24\frac{1}{6}$ years; but, taking it at 25 years, and reckoning backwards from 1790, we find the population at the under mentioned periods would be,—

1790	3,921,000 (by census)	1715	490,000
1765	1,960,000	1690	245,000
1740	980,000	1665	122,000
		1640	61,000

Beyond the last mentioned period we cannot, for obvious reasons, carry our calculation. If we suppose 1000 settlers to have come from Europe annually for the first 33 years, these, by natural multiplication, would amount to about 60,000 at the time alluded to, that is, in 1640. The following Table, constructed from documents afforded by Seybert and Mellish, with several new calculations, gives an interesting view of the progressive changes in the different states, and in the two great classes of the population.

States or Territories.	Population including Slaves.				In 30 Years each 100 Inhabitants increased to—	Slaves.		For each 100 Free Inhabitants the number of Slaves was—	
	1790.	1800.	1810.	1820.		In 1790.	In 1820.	In 1790.	In 1820.
Vermont,	85,539	154,465	217,895	235,764	275	16	—	0,01	—
New Hampshire,	141,885	183,858	214,460	244,161	172	158	—	0,11	—
Maine,	96,540	151,719	228,705	298,335	309	—	—	—	—
Massachusetts,	378,787	422,845	472,040	523,287	138	—	—	—	—
Rhode Island,	68,825	69,122	76,931	83,059	120	948	48	1,39	0,06
Connecticut,	237,946	251,002	261,942	275,248	117	2,764	97	1,17	0,03
New York,	340,120	586,050	959,049	1,372,812	403	21,324	10,088	6,68	0,74
New Jersey,	184,139	211,149	245,562	277,575	150	11,423	7,557	6,62	2,79
Pennsylvania,	434,373	602,548	810,091	1,049,458	242	3,737	211	0,86	0,02
Delaware,	59,094	64,273	72,674	72,749	123	8,887	4,509	10,77	6,61
Maryland,	319,728	349,692	380,546	407,350	121	103,036	107,398	47,54	35,79
Virginia,	747,610	886,149	974,622	1,065,366	142	292,627	425,153	82,40	66,43
Kentucky,	73,677	220,959	406,511	564,317	765	12,430	126,732	10,29	28,97
North Carolina,	393,751	478,103	555,500	638,829	162	100,572	205,017	34,30	47,28
South Carolina,	240,073	345,591	415,115	502,741	209	107,094	258,475	80,60	105,80
Georgia,	82,548	162,686	252,433	340,989	413	29,264	149,656	54,92	78,23
Louisiana,			76,556	153,407			69,064		82,90
Tennessee,		105,602	261,727	422,813			80,097		23,37
Ohio,			230,760	581,434			—		—
Indiana,			24,520	147.178			190		0,13
Illinois,	36,691		12,282	55,211			917		1,69
Missouri,		59,856	20,845	66,586			10,222		18,15
Arkansas,				14,273			1,617		12,83
Michigan,			4,762	8,896			—		—
District of Columbia,		14,093	24,023	33,039			6,377		23,95
Mississippi,			40,352	75,448			32,814		77,02
Alabama,				127,901			41,879		48,74
Total,	3,921,326	5,319,762	7,239,903	9,638,226	246	694,280	1,538,118	21,51	18,99
Florida (supposed)				10,000					
				9,648,226					
Slaves,	694,280	889,881	1,165,441	1,538,118					
Free Persons,	3,227,046	4,429,881	6,074,562	8,110,108					

It will be observed from this table, that the rate of increase is very unequal for the different sections of the Union. The older states of Connecticut and Massachusetts have only added one-fifth to their population, in the same period in which the new states of Kentucky and Ohio have quadrupled theirs. The reason obviously is, that the more densely peopled parts of the Union, and, in particular, New England, serve as a nursery to the new states, to which they are continually sending out large draughts of emigrants. There is thus a constant stream of population pouring across the Alleghanies, from the east side to the west, to occupy the vast plain of the Mississippi; and by this gradual generation of a mighty people, as it were from a central stock, a uniformity of language, manners, and institutions, is diffused over the whole, which will cement their union, in spite of local diversities of interest, and which promises to make the countless millions, who will by and by cover North America, from sea to sea, more truly *one people* than the inhabitants of Austria, Prussia, France, Spain, or Britain, are at this day.

If we calculate prospectively from the present rate

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of increase, assuming that it will continue permanent for some time, the population, at the under mentioned periods, will be,

1845 ... 20,000,000,	1895 ... 80,000,000,
1870 ... 40,000,000,	1920 ... 160,000,000.

Before this last result is realized, some retardation will probably take place in the rate of increase. But even were the vast population alluded to in existence, the average density for the whole territory would not be greater than it is at this day in Massachusetts, and only half as great as in Italy, France, and the British Isles.

The rapid growth of the population in America becomes much more striking when we contrast it with the scarcely perceptible progress of communities in the Old World. France, which had 19,094,000 inhabitants in 1700, according to the enumeration of Marshal Vauban, had 26,363,000 in 1791. Now, according to the rate of increase which this indicates, that country would have *doubled* its population in 195 years; but the population of the United States in the same period would have increased to 220 times its first amount. The following table, which we have calculated from the best data to be obtained, shows the comparative rate of increase in different countries.

	Annual Increase on each 10,000 Persons.	Period of Doubling.
United States (according to census of 1810 and 1820),	291	$24\frac{1}{6}$ years
France, from 1700 to 1791,	34	195
Ditto —— 1791 to 1821,	48	144
England —— 1801 to 1821,	137	51
Europe for the last 30 years,	76	90

Slaves.

Slavery is nearly extinguished in all the New England States, and is hastening to its extinction in Pennsylvania, New York, New Jersey, and Delaware. In Ohio it does not exist. In Indiana and Illinois it will soon cease. In Maryland, though there has been a small absolute increase in the slave population, their number, compared with that of the whites, has diminished. In two important circumstances there is a wide difference between slavery as it exists in North America, and in the West Indies. In the former, the number of slaves no where equals that of the free inhabitants, except in South Carolina, where there is a trifling excess of the former,—and in the States where slavery exists, taken altogether (excluding those northward of Kentucky and Delaware), the blacks form only one-third of the population. But in the West India Islands, the blacks are ten, or sometimes twenty times more numerous than the whites.* In the second place, it is well known that the slaves in the West Indies continually decrease, and would speedily die out, unless kept up by new importations; but, in the United States, they double their numbers in $29\frac{1}{2}$ years, without any importation whatever. It may be safely said, that the superior humanity of the Americans in the treatment of the blacks is the greatest obstacle to that abolition of slavery which they so ardently wish to accomplish, and that, were their slaves worked and fed like those in the West Indies, the race of blacks, instead of multiplying tenfold in the course of one century, would be entirely extinguished. The existence of slavery is a bequest from Britain; it is not the crime of the Americans, but their misfortune. It is an evil which they deplore, and of which they would gladly rid themselves if they knew how. The difficulty is, how to dispose of the slaves, whom many would be willing to manumit. The plan of carrying them back to a colony on the African coast seems absolutely chimerical; and the strong distinction of colour, with the rooted prejudices of the whites, form an insuperable bar to such an amalgamation of the two races as took place when the serfs of Western Europe were incorporated with the freemen in the fifteenth and sixteenth centuries. Time alone promises a certain alleviation of the evil, though not an absolute cure. If we separate the white and black races, the former double their numbers in $23\frac{7}{12}$ years, and the latter in $29\frac{1}{12}$, a difference apparently trifling, but which produces important results, if we reckon forwards. Supposing the ratio of increase to remain steady, in 118 years the slaves will have multiplied to 16 times, and the whites to 32 times their present numbers. And in this period, the relative proportions of the two races would be so changed, that the slaves, who form at present $\frac{10}{54}$ of the population, would then form only $\frac{5}{54}$ or $\frac{1}{11}$th. If we add the free blacks, indeed, the increase is more rapid than here assumed, but we throw these out as a compensation for the mulatto or mixed race, who are the progeny, not of blacks alone, but of blacks and whites, and a large part of whom must ultimately melt into the mass of the white population.

Males and Females.

In France and England, and probably in Europe at large, the females exceed the males by 2 or 3 *per cent.*; but, in the United States generally, the males exceed the females by nearly 4 *per cent.* In the newest States, the excess is as high as 19 *per cent.* (Seybert, p. 42.) The difference is still more striking in what relates to ages. In the United States, children form a much greater, and aged persons a much smaller, proportion of the population than in Europe. In Sweden, according to Wargentin's *Tables*, the persons under the age of 16 form 36 *per cent.* of the population; in Britain, according to the last census, 40, and in the United States 50 *per cent.* The persons aged above 45 form 22 *per cent.* of the whole population in Sweden, 18 *per cent.* in Britain, and 12 *per cent.* in the United States. This peculiarity arises from the rapidly progressive state of the population. Since the inhabitants of the United States quadruple their numbers in 50 years, a person born half a century ago belongs by his birth to a society of two millions and a half of persons, but now lives in a society of ten millions, which will fur-

* Colquhoun's *Wealth, Power, and Resources of the British Empire*, p. 40.

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Immigration.

nish four times as many old men to a future and equidistant period. The annual amount of immigration (to borrow an American word) is very variable, and its effects have been greatly overrated. The whole number of passengers who arrived, in 1817, at the ten principal ports, was 22,240, including citizens and persons on business who did not mean to remain in the country. In 1816, it was estimated at 20,000; in 1818 and 1819, at 28,000 each, not more than one-half of whom, very probably, were strangers come to settle. In 1820, the true number of immigrants, according to the *National Calendar*, was 7001, of whom 5042 were males, consisting of 997 agricultural persons, 1461 commercial, 1407 manufacturers, artizans, &c. Dr Seybert thinks the average number of foreigners who come to settle in the United States does not exceed 6000 *per annum;* but assuming it to be 8000 or 9000, this is only from $\frac{1}{30}$ to $\frac{1}{35}$ of the whole annual increment, which must amount to 290,000 persons to make the population double in $24\frac{1}{6}$ years.*

This rapid increase does not greatly affect the rate of the annual mortality, which is proportionally rather greater among the persons under 25 than among those of all ages. In the absence of proper data for ascertaining the annual mortality of the whole country, or of any single state, we can only refer to a single fact. The average number of deaths in Philadelphia, for eight years (1807 to 1814), was found to be about $\frac{1}{45}$ of the contemporaneous population. (Seybert, p. 50.) In Birmingham, in the ten years ending 1811, it was about $\frac{1}{36}$, in London $\frac{1}{31}$, and in all England, including the army and navy, about $\frac{1}{44}$ or $\frac{1}{45}$. (Milne's *Annuities*, p. 456.) This single fact, therefore, so far as it goes, bears testimony to the salubrity of the climate, and to the comfortable condition of the inhabitants of the United States.

Mortality.

Classes.

The active population in the United States is proportionally greater, and the idle population less than in any other country. They have few public functionaries, preachers, or annuitants, and a very small army and navy. According to a table which will be found farther on, the active population amounts to 27 *per cent.* of the whole, or 2 *per cent.* more than the number of males above the age of 16. The proportions employed in agriculture, manufactures, and commerce, according to the census of 1820 were,—

Agriculture,	83.7 *per cent.*
Manufactures,	13.5
Commerce,	2.8
	100.

But the number assigned to commerce evidently does not include mariners, or includes only those who resided on shore at the time the census was taken. For the sake of comparison, we give the general result of the British returns for 1811, remarking, however, that the two classifications are not constructed on the same plan, the second head in our arrangement corresponding to the second and third in the American.

Agriculture (by families)	$35\frac{1}{3}$ *per cent.*
Trade, manufactures, and handicraft (do.)	$44\frac{1}{3}$
Other persons (the unproductive class, military, placemen, clergy, &c.)	$20\frac{1}{3}$
	100

Wages and Pauperism.

The situation of the labouring classes in the United States is confessedly far superior to that of the same description of persons in any other part of the world. Wages are so high, compared with the price of provisions, that an American labourer, who should live exactly as labourers live in other countries, might always save the half of his earnings. The average wages of a labourer were estimated at 75 *cents* a day by Mr Blodget, and more recently at 80 *cents* by Mr Niles, wheat being $1\frac{1}{2}$ dollar *per* bushel. (Warden, Introduction.) In such circumstances, a very moderate degree of industry suffices to place a man above want, and pauperism can only be the lot of those who are debilitated by old age or disease. Accordingly, it is a proud distinction for North America, that this moral deformity, except so far as it is the consequence of natural and unavoidable misfortunes, is almost unknown within her borders. It is not there as in the old countries of Europe, where a person, who is able to provide comfortably for his own wants, has still his feelings exposed to daily laceration from the sight of multitudes of miserable beings, who exhibit human nature in its most loathsome and degraded state, and whose wretchedness it is beyond his power to relieve. It is Rochefoucault, we think, who remarks, that he had seen only one beggar in the United States. Mendicity does exist, but except in the large cities where foreigners are often found in a state of destitution, it rarely obtrudes itself on the eye, and may be said generally to be as rare in that country as it is abundant every where else. In Europe, the paupers have been supposed, on a rough calculation, to amount to one-twentieth part of the population. In the United States, they were estimated by Mr Niles, some years ago, at one person in 250 on the Atlantic coast, and one in 350 in the interior. But, in times of great public calamity, the proportion is much higher. In the New England States, and in some of the others, though not the whole, each parish is obliged to provide for the support of its own poor, according to the humane spirit of the English laws. (Morse, Vol. I. 293. Warden, *passim.*)

States.

The North American Union comprehends at present *twenty-four* distinct States, each governed by its own constitution; *three* territories, in which civil governments are established, without constitutions;† and

* Seybert, p. 28. Carey's *Essay on Political Economy*, 1822, p. 453, 467. Nile's *Register*.

† A territory becomes a state when its inhabitants, amounting to not less than 60,000 persons, have met and formed a constitution. Previous to this, they are placed under the civil authority of a governor, appointed by the President and Congress.

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three other territories, which are yet unoccupied by a civilized population. To these we must add the district of Columbia, comprising a space of ten miles square round Washington, which is placed under the exclusive authority of that Federal Government.

The following Table gives a view of the extent, population, and representation of each State, and of the proportion of its inhabitants engaged respectively in agriculture, manufactures, and commerce, according to the census of 1820.

States and Territories.	Square Miles.	Population.	Agriculture.	Manufactures.	Commerce.	Population in each Square Mile.	Senators.	Representatives for 1823.
STATES.								
Maine,	32,000	298,335	55,041	7,643	4,297	$9\frac{1}{3}$	2	7
New Hampshire,	9,280	244,161	52,384	8,699	1,068	26	2	6
Vermont,	10,200	235,764	50,951	8,484	776	23	2	5
Massachusetts,	7,800	523,287	63,460	33,466	13,301	67	2	13
Rhode Island,	1,360	83,059	12,559	6,091	1,162	61	2	2
Connecticut,	4,670	275,248	50,518	17,541	3,581	59	2	6
New York,	46,200	1,372,812	247,648	60,038	9,113	30	2	34
New Jersey,	6,900	277,575	40,811	15,941	1,830	40	2	6
Pennsylvania,	43.950	1,049,458	140,801	60,215	7,083	24	2	26
Delaware,	2,060	72,749	13,259	2,821	533	35	2	1
Maryland,	10,800	407,350	79,135	18,640	4,771	38	2	9
Virginia,	64,000	1,065,366	276,422	32,336	4,509	17	2	22
North Carolina,	43,800	638,829	174,196	11,844	2,551	15	2	13
South Carolina,	30,080	502,741	166,707	6,747	2,684	17	2	9
Georgia,	58,200	340,989	101,185	3,557	2,139	6	2	7
Alabama,	50,800	127,901	30,642	1,412	452	$2\frac{1}{2}$	2	2
Mississippi,	45,350	75,448	22,033	650	294	$1\frac{2}{3}$	2	1
Louisiana,	48,000	153,407	53,941	6,041	6,251	3	2	3
Tennessee,	41,300	422,813	101,919	7,860	882	10	2	9
Kentucky,	39,000	564,317	132,161	11,779	1,617	$14\frac{1}{2}$	2	12
Ohio,	38,500	581,434	110,991	18,956	1,495	15	2	14
Indiana,	36,250	147,178	61,315	3,229	429	4	2	3
Illinois,	59,000	55,211	12,395	1,007	233	1	2	1
Missouri,	60,300	66,586	14,247	1,952	495	1	2	1
TERRITORIES.								
Michigan,	33,750	8,896	1,468	196	392	$\frac{1}{4}$		
Arkansas,	121,000	14,273	3,613	179	79	$\frac{1}{8}$		
Florida,	57,750					$\frac{1}{6}$		
North-west Territory,	144,000							
Missouri Territory,	930,000							
Columbia Territory,	288,000							
District of Columbia,	100	33,039	853	2,184	512	30		
Totals,	2,364,400	9,638,226	2,170,646	349,506	72,493		48	212

The *thirteen* original States which concurred in the declaration of independence on the 4th July 1776, were New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North Carolina, South Carolina, Georgia. Vermont was then an appendage to New York, and Maine to Massachusetts. The extent of the several States is very unequal. Rhode Island and Delaware are specks in the map, rather smaller than Devonshire or Perthshire. New York, Pennsylvania, and the New States generally, are each larger than Ireland or Scotland; while Virginia, Georgia, Missouri, and Illinois, severally exceed England in extent. The density of the population varies from one person *per* square mile to 67. It diminishes pretty regularly in every direction as we recede from Massachusetts, and in that State, where it is greatest, it rather exceeds that of Spain, or Poland, or Europe, taken altogether. The mean density for all the *States* east of the Mississippi, and including Louisiana, is 13 persons to the square mile, which rather exceeds that of Sweden and Norway.

State Governments.

Some writers, who derive their political ideas from the old institutions of Europe, disapprove strongly of the division into states, with distinct local governments. But this arrangement, though originally the effect of accident, is admirably adapted to the circumstances of the country, and deserves to rank as an improvement in the science of legislation. It is

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the only system by which the great advantages of union could be combined, in such a gigantic empire, with a due attention to the separate interests of all the parts. The federal compact, by preserving peace and friendship among states that would otherwise be rivals and enemies, exempts them from the scourge of frequent wars, gives unbounded freedom to their internal trade, and, while it enables them to dispense with that sort of strong government which is scarcely compatible with liberty, it gives them an aggregate strength, which secures them against external attacks. On the other hand, each separate district, acting by its own legislature, is invested with the entire regulation of its local concerns, which can never be entrusted to others without the certainty of mismanagement. No single legislative body, even were its sessions perpetual, could properly conduct the local business of such an empire as that now forming in North America. In our own Parliament, it is notorious, that, from the multiplicity of business transacted, the general style of legislation is most slovenly, and bills of all kinds, but especially local bills, are often grossly mismanaged. How great an impediment is it felt to be to the redress of grievances, or the promotion of improvements, in the remote parts of Scotland and Ireland, that witnesses, parties, and agents, must be carried six or seven hundred miles at a vast expence, and that, when at the seat of legislation, their success must greatly depend on the votes of persons who either understand their business imperfectly or not at all, and who are only prevailed upon to bestow a slight attention upon it by private solicitation. The division into states supplies the only remedy to this great evil. It encourages local improvements by uniting those whose situation gives them a community of interest as to certain objects. It lessens corruption in the general government, by subdividing patronage. In times of public frenzy, it multiplies the securities against the persecution of individuals, because such persons will always find protectors in some one of the state governments. It has, indeed, one disadvantage; the state legislatures may become the strong-holds of faction, as exemplified in Massachusetts during the last war. But, as the number of States increases, the weight of each in the confederacy, and its power to disturb the union is diminished. Even out of this danger a security arises against another. The existence of the separate state governments forms a strong barrier against despotism, because it creates so many distinct centres of power, from which resistance might be made, if a military tyrant should master the general government, as Cromwell mastered that of England, and Bonaparte that of France. Some inconvenience, no doubt, arises from the unavoidable diversity of laws in such an aggregation of republics; but the evil is not much felt or complained of practically, and it is the necessary concomitant of a union producing boundless advantages. An iron despotism may subject all its slaves to the same laws without regard to the distinctions of climate, character, or situation; but freemen will not associate voluntarily on such a principle. Liberty consists, not in being governed by the laws that are absolutely best, but by those which are deemed best by the people who obey them. No wise and liberal statesman will hold it necessary that the fishermen of Massachusetts, the husbandmen of Pennsylvania, and the sugar planters of Louisiana, should live under one perfectly uniform system of jurisprudence. Such a uniformity could not be enforced without rending asunder the union. And let it be recollected, that the diversity of laws, such as it exists, is much less than it would be if the federal compact were dissolved, and the several States entirely independent. In short, if it is possible by any device to reconcile freedom with extensive empire; to unite all the parts of a vast continent together in the bonds of peace and commercial intercourse; and yet not to trench materially on the natural rights of each part, or the free use of its natural powers and advantages; it must be by a federative system similar in its essential characters to that of the United States. The experiment is by far the most interesting that has ever been made in the science of legislation, and the steadiness and success with which it has hitherto proceeded opens up the most encouraging prospects as to the future destiny of mankind.

The federal government, of which we shall speak afterwards, possesses merely those specific powers which are vested in it by the Constitution. All other powers and rights remain with the state governments, in whom the sovereignty essentially resides. The territory of each state is not the territory of the Union, but of that particular State. The people and militia are the people and militia of the several States, not of the Union. Lands are held under the laws of the States; descents, contracts, and all the concerns of private property, the administration of justice, and the whole criminal code, except in the case of breaches of the laws of the federal body, are regulated by state laws.* All the twenty-four States have written constitutions, formed subsequently to the Revolution, except Rhode Island, which is still governed by the charter granted by Charles II. in 1663. These constitutions are purely republican, though the right of suffrage (for the term *franchise* is inapplicable and odious where voting is a general right, not a special privilege) is restricted in one or two States, and unequally divided in one or two others. In every one of the States the legislature consists of two chambers, both chosen by direct popular election, except in Maryland, where the senators are chosen by delegates. In nineteen States out of the twenty-four, the representatives (or members of the Lower House, according to our phraseology) are elected annually, and in five triennially, viz. in South Carolina, Tennessee, Louisiana, Illinois, and Missouri. The period of service in the senates (or Upper Houses) varies from one to four years, except in Maryland, where it is five: in some cases one-third

State Constitutions.

* *Views of the President of the United States on the subject of Internal Improvements, laid before Congress, 4th May* 1822.

or one-fourth, in others one-half of the members are renewed every year; in others, one-half every two years. In some of the States the right of suffrage was formerly limited to freeholders or corporations, but by amendments in most of the old constitutions, these odious and really impolitic restrictions have been abolished; and the right of suffrage, though variously defined in the different States, is substantially universal in them all, except in New Jersey and Virginia. In these two States, the possession of a small amount of property still constitutes the citizen's title to vote. In many of the States there are certain qualifications prescribed for the persons elected. A senator must, in general, be a freeholder, and not under 30 years of age; a representative not under 25. The governors act, in some cases with, in others without a council, and hold their offices, some for one year, some for two, some for three, but none for more than four years. In all the constitutions recently framed an express provision is introduced for adopting amendments. The rule generally is, that if any alteration is judged necessary and approved of by two successive legislatures, it may then be submitted to the people, who appoint a special convention to decide upon it. In some cases it is provided that a convention shall meet periodically to revise the constitution. The existing legislature is always considered as exercising a trust, in the terms of which it has no power to make the smallest change. By this principle, legislation is founded on a clear and rational basis. It gives stability to institutions that might otherwise be the foot-ball of domineering factions; it checks the growth of sinister interests, and, while it affords a safe and easy remedy for grievances, it is so far from being an inlet to rash innovations, that it is the best guarantee against them; as the history of the United States demonstrates. To suffer those who exercise the supreme power of a country to change at pleasure the conditions by which they hold it, is equally as absurd as to suffer the judge to make the laws he administers, or the steward to fix the terms of the engagement which invests him with the management of an estate. Under such a system, the steward unavoidably becomes a peculator, the judge a tyrant, and the legislature a junto of conspirators against the public weal.

Agriculture. The agriculture of the United States varies according to the climate, soil, and situation, of the several divisions of the country; but, taken altogether, it differs materially from that of Britain,—in the nature of the productions cultivated, in the condition of those who are engaged in it, and in the general principles by which it is conducted. Besides our staple productions, wheat, barley, oats, pease, beans, turnips, and potatoes, the soil of the United States yields rice, Indian corn, indigo, cotton, sugar, tobacco, the vine; and Florida will probably add to these the olive and the banana, which scarcely succeed in the other States. The staple produce of New England is Indian corn; that of the middle States, wheat and tobacco; that of the southern, cotton, rice, and, to a limited extent, sugar. Dr Morse indicates the proportional quantity of each species of produce raised, by naming them in the following order, the greatest being first: In New England, Indian corn, grass, rye, oats, flax, wheat, buck-wheat, barley, and hemp; in the middle States, wheat, Indian corn, tobacco, grass, oats, buck-wheat, flax, barley, potatoes, spelts, rye; in the southern States, cotton, wheat, tobacco, Indian corn, rice, indigo (formerly), barley, and hemp. The western States, along the Ohio, correspond in their productions to the middle States, on the Atlantic. Good soils, carefully cultivated, in the United States, yield 100 bushels of Indian corn, or 50 of wheat *per* acre. But the average produce of the cultivated land in Ohio and Kentucky, districts not inferior in soil to any in the Union, is estimated as follows: maize 40 bushels *per* acre, wheat 22, rye 26, oats 35, barley 30, tobacco 12 to 15 cwt., cotton 5 to 7 cwt. in the seed, or from 150 to 200 pounds cleaned. (James, Vol. III. p. 199.) An acre sown in rice yields from 1200 to 1500 pounds on what are called tide lands, and from 600 to 1200 on inland plantations. An acre planted in canes yields about 1000 or 1200 pounds of sugar, with an equal quantity of molasses. The necessity of renewing the canes annually by planting, in consequence of the winter's frost, renders the cultivation less advantageous than in the West Indies. In 1817, however, it was calculated that 20,000,000 of pounds of sugar were made in Louisiana alone, which was estimated to be about $\frac{2}{7}$ of the whole annual consumption of the United States. (Warden, II. p. 483, 541. Morse, I. p. 668.)

The rural population of the United States presents an extraordinary contrast in its constituent parts to that of every country in Europe. The class of extensive proprietors living on their rents, and the class of peasants living merely by their labour, are almost equally unknown. The great bulk of the inhabitants consists of farmers, who are the owners of the lands they occupy, and the greater proportion of whom work with their own hands. "The number of those who are mere labourers," says Dwight, "is almost nothing, except in a few populous towns, and almost all these are collected from the shiftless, the idle, and the vicious. A great part of them are foreigners. Every young man hired to work upon a farm aims steadily to acquire a farm for himself, and hardly once fails of the acquisition." (Dwight's *Travels*, Vol. IV. p. 335.) Except in some few spots near large towns, there is scarcely any land rented. The price is generally so low, that a small addition to the sum necessary for stocking a farm suffices to purchase it; and even where the value is higher, an individual who has money enough to stock a large farm will prefer buying one of half the size. Of the State of New York, only one-fifth, and of the whole inhabited country east of the Mississippi (excluding Michigan and Florida), only about one-tenth part is yet cleared and cultivated. Of course, the best soils are first used, and, till population thickens and produce rises, soils of the second and third quality will not repay the expence of culture; and as a necessary consequence, those of the first quality yield no rent. The farms occupied by the owners are seldom large, because, where wages are high, agriculture cannot be advantageously conducted on an extensive scale; and the large property in land occasionally acquired by an individual is soon broken up by division among

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his children. Thus situated, the rural population certainly enjoy a greater share of happiness in the United States than in any other country in the world. They are exempted from the fluctuations incident to the commercial and manufacturing classes; they feel none of the evils of dependence, and are far above want; without possessing that wealth which engenders idleness and vanity, and often becomes a snare to its possessor. They have the means of settling their families well, without making great sacrifices; they live in the enjoyment of all the substantial comforts of life, and can look forward to old age with less anxiety and apprehension than any class of men in any other country.

The system of agriculture is necessarily less perfect in the United States than in Britain. Where prime soils can be had for almost nothing, where the price of labour is high, and that of produce low, the elaborate and costly modes of cultivation adopted in Britain cannot be advantageously applied. Some English farmers, who have gone out to America with an impression that large gains might be made by introducing our improved system of husbandry, have found themselves disappointed. Something the Americans may learn from us; but, till the country is more densely peopled, it will be more profitable to cultivate a large surface rudely than a small one laboriously. In the middle and eastern States, however, where produce brings a considerable price, farming is carried on with care and skill. In Pennsylvania, which holds the first rank as an agricultural state, in New York, Massachusetts, Connecticut, and Jersey, agricultural societies exist, and much attention is paid to the cultivation of the indigenous grasses and to the use of manures. Grazing is well understood in New England, where it is considered the most profitable species of farming. Much care has been bestowed on the breeding of sheep, and Merinos are now spread over all the northern, middle, and western States.

Hutchins reckoned that $\frac{13}{16}$ths of the land east of the Mississippi was covered with a strong fertile soil. The remaining $\frac{3}{16}$ths were occupied by lakes and rivers, or consisted of land too poor or too steep for cultivation. In 1811, Mr Blodget estimated the land under "actual improvement" to be 40,950,000 acres, or $5\frac{3}{4}$ acres for each inhabitant, a proportion which is found to be near the truth. In 1798, when a census was taken for the imposition of a tax, the quantity of land valued and taxed in sixteen States was one hundred and sixty-three millions of acres out of three hundred and eight millions, the estimated value of which was four hundred and seventy-nine millions of dollars. The value *per* acre varied widely. In Connecticut it was fifteen dollars *per* acre, in Pennsylvania six, in Georgia three-fourths; but the average for the whole was about three dollars. The value of the houses was estimated at a hundred and forty millions of dollars, or two-sevenths of that of the land. When new returns were procured in 1814, the value of lands and houses conjointly had risen from six hundred and twenty to one thousand six hundred and thirty millions of dollars. From these two documents, which afford a curious view of the state and growth of property in the republic, we find that, in the sixteen States organized, in 1798, rather more than one-half of the surface was the property of individuals. In the old States, such as Massachusetts and Connecticut, the appropriated land embraced nearly the whole surface; in New York, it embraced about four-sevenths, in Georgia one-third. The number of acres appropriated for each individual of the population was about thirty, of which five and one-half or six acres were cleared or "improved." The estimated value of the houses and lands was at the rate of 125 dollars for each individual of the contemporaneous population in 1798, but had risen to 200 dollars in 1814. Supposing every other species of property to have grown as rapidly, the rate of increase would be about $6\frac{1}{4}$ *per cent. per annum*, and the capital of the country must double itself in $11\frac{1}{4}$ years, or it increases twice as rapidly as the population. With a stationary population, the rate of increase would be 5, 4 *per cent.*, and the period of doubling $13\frac{1}{4}$ years. We have no similar data for other countries to found a comparison on, but we are certain that such a velocity of accumulation is unknown anywhere else.

The value of houses, lands, *and slaves*, in 1814, was, according to the returns, 1902 millions of dollars. If we add one-eighth for omissions and under estimates, and for Louisiana, which was not included, with 50 millions for state lands, and two-thirds additional for all other species of property (this being nearly the proportion in Colquhoun's estimate for Britain); namely, agricultural stock, manufactured goods on hand or in progress, ships, harbours, canals, roads, public buildings, &c.—the whole will be 3550 millions of dollars, equal to 780 millions Sterling, or about L. 95 for each individual of the contemperaneous population. Colquhoun's estimate for Britain was 2700 millions Sterling, or L.150 for each inhabitant. This gross amount, increasing at the rate of 6 *per cent.* would become 1400 millions Sterling in 1824, and the annual increment, or the value added to the national capital every year, should be about 80 millions Sterling. The whole annual produce of the national industry, which affords a saving of 80 millions, cannot be less than four times as much, or 320 millions, that is, L. 32 *per* head on the population. Colquhoun's estimate for the British Isles in 1812, was 430 millions, or L. 24 *per* head on the population. (Colquhoun, p. 55, 65.) These calculations are founded on the returns taken as they stand. It is probable, however, that the second census would be more accurately taken than the first, and that the growth of the national capital is not quite so great as it appears.

Manufactures and Mechanic Arts.

The large profits which farming yields, and the high price of labour, are discouragements to manufacturing industry in the United States. The arts in which they have made the greatest progress, are cabinet and coach making, shoemaking, steam-boat and ship building, the construction of mill machinery and wooden bridges, and bank-note engraving. Piano-fortes are respectably made. The saw gin for cleaning cotton from the husks, and the nail-making machine, are American inventions. The woollen manufacture is almost entirely domestic, being carried on in the houses of the farmers; but the cotton manufac-

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ture is partly conducted in large works. This last, as well as several other manufactures, received a great stimulus during the late war with Britain, but they have declined since the peace, though a few of the works then established are still carried on with advantage. It was computed by a Committee of Congress, that the cotton manufactures, which consumed only 10,000 bales of the raw material in 1810, consumed 90,000 in 1815; employed 100,000 hands (10,000 men, 66,000 women and girls, 24,000 boys), and produced 81,000,000 yards of cloth, valued at 24 millions of dollars. The value of the woollen manufacture was estimated at 19 millions of dollars, and was supposed to employ 50,000 hands constantly, and as many more occasionally. (*Reports* of 13th February and 6th March 1816.) According to the returns made in the census of 1810, the whole annual value of the manufactures of the United States was 127,694,602 dollars. But Mr Tenche Coxe calculated, that, making allowance for articles omitted or under-estimated, the true value would not be less than 172,700,000 dollars (L. 37,500,000.) If the increase in this branch of industry has kept pace with the growth of the population, it should now amount to 240 millions (L. 52,000,000.) But the value of the manufactured goods imported in 1821 was only 32 millions of dollars, and deducting five millions re-exported, the quantity which remains for home consumption is only 27 millions, or *one-ninth* part of the whole. It is against this small fraction of the annual consumption that such an outcry is made; and that the Americans, borrowing our exploded maxims, are fencing themselves by such an apparatus of protecting duties, prohibitions, and restrictions. For the purpose of comparison we may mention, that Chaptal estimated the annual value of the French manufactures, in 1820, at L. 72,800,000, which is probably a good deal under the truth; and that Colquhoun estimated that of the British manufactures at L. 116,000,000 in 1812, exclusive of the raw material. Of the manufactures returned in the census of 1810, valued at 127,694,602 dollars, the following were the most considerable:

Goods manufactured by the loom 39,500,000 dollars.
Machinery of various kinds.........6,100,000
Hats 4,300,000
Iron manufactures.................14,360,000
Leather 17,900,000
Distilled and fermented liquors...16,530,000
Wooden articles 5,540,000

According to the returns, there were 153 iron furnaces, 34 rolling and slitting mills, 325,392 looms, 122,647 spindles for yarn, 141,191 distilleries, producing 22,977,167 gallons of spirits from grain, and 2,827,625 from molasses, 132 breweries, 208 gunpowder mills. Nearly one-fourth of the manufactures were in Pennsylvania; Massachusetts ranks next, then New York, Virginia, Maryland, Connecticut, North Carolina, New Jersey, Vermont, Kentucky. It may be remarked, that the effect of the high price of labour in discouraging manufactures is counteracted by three circumstances. 1. The United States being far distant from Europe, the expence of freight, and still more that of inland carriage, makes a material addition to the prime cost of all bulky or heavy articles. 2. As the use of machinery comes to be substituted more and more for manual labour, the disadvantage of high wages gradually vanishes; and the Americans, who possess great mechanical genius, have the means of procuring steam and water power to an unlimited extent. 3. The American women prefer working in factories to domestic service, which they consider degrading; and hence female labourers are not scarce, and may be procured at moderate wages. *

Commerce.

The commerce of the United States has made much greater progress than their manufactures. The wars and convulsions of Europe, consequent on the French Revolution, threw a great proportion of the general carrying trade into their hands; and in the interval, from 1790 to 1807, their exports increased from 20 millions to 108 millions of dollars. But the Berlin Decrees and the British Orders in Council gave a sudden check to this growing prosperity, and the foreign trade of the United States has never since reached so great a height. The following table shows the amount of exports, distinguishing foreign from domestic produce, from 1800 to 1821:

Years.	Exports.	Domestic Growth, Produce, or Manufacture.	Foreign.
1800	70,971,780	31,840,903	39,120,877
1801	94,115,925	46,377,792	46,642,723
1802	72,483,160	26,182,173	35,774,971
1803	55,800,033	42,205,961	13,594,072
1804	77,699,074	41,467,477	36,231,597
1805	95,566,021	42,387,002	53,179,019
1806	101,536,963	41,253,727	60,283,236
1807	108,343,150	48,699,692	59,643,558
1808	22,430,960	9,433,546	12,997,414
1809	52,203,283	31,405,702	20,797,531
1810	66,757,970	42,366,675	24,391,295
1811	61,316,833	45,294,043	16,022,790
1812	38,527,236	30,032,109	8,495,127
1813	27,855,997	25,008,152	2,847,845
1814	6,927,441	6,782,273	145,169
1815	52,557,753	45,974,403	6,583,350
1816	81,920,452	64,781,896	17,138,556
1817	87,671,566	68,313,500	19,358,069
1818	93,281,133	73,854,437	19,426,696
1819	70,142,521	50,976,838	19,165,683
1820	69,691,669	51,683,640	18,008,029
1821	64,974,382	43,671,894	21,302,488

The imports have not been regularly published. For 1821, they amounted to 62,585,724 dollars in

* Seybert, 6, 8. Mellish, 90. Warden, III. 262. Fearon, 389, &c.

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value, from which deducting bullion and articles re-exported, there remain for domestic consumption 43,696,405, of which the leading articles were,—

Woollens	6,959,000	Wines	1,632,000
Cottons	6,665,000	Spirits	1,640,000
Silks	3,430,000	Molasses	1,708,000
Linens	2,318,000	Teas	1,081,000
Iron and iron-ware	2,969,000	Coffee	2,403,000
Hemp, &c.	1,271,000	Sugars	1,905,000

The imports and exports were chiefly from the following countries:

	Imports from	Exports to
Russia	1,852,199	628,894
Holland	1,938,953	3,694,205
British Isles	25,087,108	20,777,479
France	5,989,940	5,528,559
Spain	542,393	539,746
Portugal	356,116	147,792
Italy and Malta	973,463	1,099,667
Sweden	759,753	217,181
Cuba	6,584,849	4,540,680
Hayti	2,246,257	2,270,601
Spanish South American Colonies	1,114,117	1,037,735
Hanse Towns and Germany	990,165	2,132,544
Brazil	605,126	1,381,760
China	3,111,951	4,290,560
British East Indies	1,530,799	1,966,279
British West Indies	927,346	265,102

The following table (from Carey and Lea's *Atlas*) shows the tonnage of each State, and of the whole Union, in 1821:

Maine	122,856
New Hampshire	23,335
Massachusetts	316,069
Rhode Island	39,314
Connecticut	45,724
New York	244,338
New Jersey	34,533
Pennsylvania	83,575
Delaware	10,043
Maryland	125,149
District of Columbia	24,677
Virginia	63,326
North Carolina	38,864
South Carolina	29,944
Georgia	14,662
Mississippi	6,131
Louisiana	38,815
Kentucky and Ohio	598
Michigan	665
	1,262,618

Registered tonnage employed in foreign trade	619,029
Enrolled and licensed tonnage employed in coasting trade	588,014
Ditto ditto in fisheries	55,575
	1,262,618

It will be seen from these tables, that since the peace, foreign produce or manufactures constitute about one-fourth, and domestic three-fourths of the exports. The leading articles are raw produce. Cotton forms about 46 *per cent.* of the domestic exports; wheat, Indian corn, and other breadstuffs, 15 *per cent.*; tobacco, 13 *per cent.*; lumber, bark, &c. 6 *per cent.*; horses, beef, &c. 5 *per cent.* The leading imports are the fine products of the loom in wool, cotton, silk, linen, or articles not raised in the country, such as tea, coffee, sugar, wine. In hemp, iron, and leather, the imports are small. About four tenths of the whole imports come from Britain, and only about one tenth from France.

The internal and coasting trade of the United States has increased more rapidly than their foreign commerce, and is undoubtedly far greater than that of any other state with an equal population. The enrolled and licensed tonnage, which was only 184,000 tons in 1795, had risen to 588,000 in 1821. It is now equal to the registered tonnage, of which it formed only one-third in 1795, and it has more than tripled in the period in which the population has doubled. The Hudson, which is the great channel of inland trade, for districts containing nearly two millions of inhabitants, has, according to Palmer and other recent travellers, 2000 sloops and schooners plying upon it,—a greater number than belonged to all Scotland in 1810. The Delaware, Susquehannah, Potowmac, and other large rivers farther south, are all the scene of an active and growing traffic. The majestic Mississippi, though it does not yet rival the Hudson, must in time far surpass it. The invention of steam-vessels has done for the navigation of rivers what the invention of sails did for that of the ocean. The United States had the honour of introducing this admirable improvement; and they make a more extensive use of it than any other country in the world. In the evidence given by Mr Perkins of New York before a Committee of Parliament in 1822, he stated there were about 300 steam-boats employed in the United States, and of these about one-half used high pressure engines. On the Mississippi alone, according to a recent American paper, there were 78 in 1823, measuring 14,338 tons, or about 184 tons on average.

Canals.

The great facilities for inland navigation which nature has bestowed on the United States, have been improved by art; and considering the sparseness of the population, the number of canals which have already been formed is truly surprising. The Middlesex Canal, in Massachusetts, completed many years ago, is 31 miles long and four feet deep, and cost 700,000 dollars. The Lake Champlain Canal, which joins the Hudson at Fort Edward, is 22 miles long, and four feet deep, and was to be finished in 1823. A canal, 22 miles long, connects Chesapeake Bay with Albemarle Sound. Another of the same length joins Santee and Cooper Rivers in South Carolina. Besides these, ten or twelve canals, from one mile long to seven or eight, either finished or in progress, are enumerated by American writers. Many others are projected, among which are one of 28 and another of 22 miles in length, to connect the Rariton and Delaware rivers with Chesapeake Bay. If these were completed, an uninterrupted inland navigation

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would exist for nearly 500 miles, from New York to Pamlico Sound. But the greatest work of the kind in the United States, and perhaps in the world, is the Great Canal which unites the Hudson with Lake Erie. It begins in the neighbourhood of Albany, passes along the course of the Mohawk River to Rome, then proceeds westward, keeping at a variable distance of 10, 15, or 20 miles from Lake Ontario, and terminates in Lake Erie at Black Rock, a mile from Buffaloe. It is 362 miles long, 40 feet wide at top, 28 at bottom, and four in depth. Its termination in Lake Erie is 564 feet above its origin in the Hudson; but the aggregate rise and fall is 654 feet, and is effected by 81 locks. The canal, which is the property of the State, was begun in 1817, and finished in 1823, except about 30 miles, which will be completed in 1824. It is believed the whole expence will rather fall short of the estimate, which was five millions of dollars (L. 1,100,000). The freight is about a dollar *per* ton, each 100 miles, to which is to be added tolls at the following rates: for salt and gypsum 50 cents—grain, flour, &c. 150 cents—and merchandise, 300 cents *per* ton for each 100 miles. This great undertaking, almost equalling in magnitude, and far surpassing in utility, the most magnificent works of Imperial Rome,—executed by a State with a million and a quarter of inhabitants, affords a gratifying proof of the energy and enterprise generated by free institutions.

Banks.

No country has suffered so much from the mania for banking, or been so deluged with depreciated and worthless paper money, as the United States. There were 400 banks in existence in 1819, three-fourths of which probablyhad only fictitious capital. They were got up generally by knots of speculating tradesmen and lawyers, often without depositing a dollar beyond what was necessary to pay for paper and engraving. Even the respectable banks issue notes for a single dollar; but in the western country, where these establishments were on the worst footing, notes were issued for a half, a quarter, an eighth, and even a sixteenth of a dollar! The immense mass of worthless paper money they put into circulation created a transient and hollow prosperity, which was followed by a degree of embarrassment and distress that had almost the character of a general bankruptcy. The paper bubbles burst, one after another, with extraordinary celerity, and involved multitudes in ruin. Of a hundred banks in Ohio, Kentucky, Tennesse, and Indiana, there were only two whose notes were received at the land offices. In some of these States acts were passed by the legislature suspending legal proceedings to compel payment of debts. It may be imagined what an extraordinary derangement was produced in the state of property, when the circulating medium was reduced in three years (1815 to 1819) from 110 to 45 millions of dollars.*

Revenue.

The United States present the singular spectacle of a government supported without internal taxes. The public revenue is derived entirely from the customs and the sale of public lands; for the post-office merely defrays its own expence, and the sums that stand in their accounts as bank dividends, are but the produce of money previously invested. Small imposts, indeed, are levied for the support of the state governments, but these on an average probably no not exceed one dollar for each inhabitant, or ten million of dollars for the whole Union. The public revenue of the federal government amounted to 14,264,000 dollars in 1821, and to 20,232,427 for 1822. For 1823 they were estimated at 20,444,035 dollars, and for 1824 at 18,550,000, composed of the following items—

	Dollars.	In British Money.
Customs -	16,500,000	L. 3,630,000
Public lands -	1,600,000	350,000
Bank dividends -	350,000	77,000
Arrears & repayments	100,000	22,000
	18,550,000	L. 4,079,000

The estimated expenditure for 1824 was—

	Dollars.	In British Money.
Civil, Diplomatic, and Miscellaneous,	1,814,057	L. 399,000
Military department, including Fortifications, Ordnance, Pensions, Army, Militia, and Indian department,	5,122,268	1,127,000
Naval service, including gradual increase of the Navy,	2,973,927	654,000
Public debt, -	5,314,000	1,169,000
	15,224,252	L. 3,349,000

The public debt, which amounted to 123,630,000 of dollars in 1816, was reduced to 90,177,962 dollars (L. 19,800,000 Sterling) at the 1st January 1824; one-fourth of the whole having been paid off in the intervening eight years. A farther reduction of ten millions will, it is supposed, take place at the 1st January 1825, from an accumulating balance or surplus in the Treasury. The Democratic party, however, would have acted more wisely, had they availed themselves of the existence of this debt to repair their great error—the abolition of internal taxes—by keeping up some of the duties imposed during the late war, till the whole amount was discharged. When peace brings an entire exemption from taxes, the burdens, which even a just and necessary war imposes, will be borne very impatiently, and the government will not receive the support necessary to carry it through an arduous struggle. During the last short war in 1813 and 1814, the clamours of the people, in consequence of burdens and embarrassments not half so serious as are patiently borne in Europe, had almost compelled the government to sacrifice the national honour by accepting peace on shameful terms.

Army.

The free spirit of the Americans, and still more,

* *Report of Secretary of Treasury on Currency*, 1820. Flint's *Letters from America*, Nos. 16 and 17.

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their parsimonious habits in public matters, make them averse to the existence of a large standing army. In this, as in some other things, they, perhaps, carry their opposition to the practice of the European States too far. Regular troops can be effectually opposed only by regular troops; and, in the present condition of the world, the state which denudes itself of efficient defensive weapons, may be said to court disaster and disgrace. To supply the want of a small number of regular troops by masses of raw militia six times as numerous, who leave their homes under great personal and pecuniary sacrifices, is not economy, but the reverse,—to say nothing of the certain losses it occasions, and the humiliations these produce to natural feeling. After the close of the late war, the Congress, by act of 3d March 1815, fixed the strength of the regular army at 9980 men, but it has since been reduced, and its actual strength, as reported to Congress in March 1822, was—

Engineers	23
4 Regiments of Artillery	1977
7 Do. of Infantry	3367
Ordnance men	53
	5420

The army is distributed at about fifty posts and places along the sea-coast and inland frontier. The pay of a colonel of infantry is seventy-five dollars (L. 16, 10s.) *per* month, and six rations a day—of a captain, forty dollars and three rations—of a first lieutenant, thirty dollars and three rations—of a sergeant, eight dollars and one ration—of a private, five dollars and one ration. The aggregate expence of the army in 1822 was 1,929,179 dollars, and the average charge for each man 299 dollars (L. 66). The Americans have a well conducted military academy at West Point, on the Hudson, where 230 cadets, between the ages of fourteen and twenty-one, are instructed in the branches of knowledge necessary to form engineers. The period of service is five years, and the expence for each pupil is about 500 dollars *per annum*. But the chief military force of the United States is the militia, consisting properly of all the males between eighteen and forty-five, but always less or more deficient. A return at the close of 1823 makes the number amount to 993,281, When called out to the field they have the same allowances as the regular army, and their period of service is limited to six months. The American militia are under the charge of the State governments. They generally, if not universally, elect their own officers, and are said to be very indifferently disciplined. *

Navy.

The exploits performed by the American ships in the last war have made the navy extremely popular. The United States had not a single ship of the line ready for sea till near the close of the contest, and they have now twelve built, or building. In 1816, Congress appropriated a million of dollars *per annum* for eight years to increase the navy. In 1821, the grant was reduced to 500,000 dollars, and continued till 1825. A small number of vessels are kept always in commission, and stationed partly in the West Indies, and partly in the Mediterranean. According to an American journal, the strength of the navy in November 1823 was as follows:—

	In Commission.	In Ordinary.	Building.
Ships of the Line ...	1	6	5
Frigates ...	3	4	5
Smaller Vessels ...	12	2	—
Steam Frigates ...	—	3	—

To these must be added vessels on the lakes, viz. two of 74 guns on the stocks, one of 44, one of 36, one of 32, one of 26, two of 24, with eleven smaller vessels, and fourteen gun-boats, some of which are much decayed. The American vessels are built larger than ours of the same class, and carry heavier guns. Their steam frigates are an improvement yet untried in aetual service, but which may probably lead to an imporant change in maritime war. The navy is managed by a Board of three commissioners, and a secretary. A small tax of twenty cents *per* month is paid by all officers and seamen, both in the navy and merchant service, for the relief of sick and disabled mariners, part of whom are lodged in hospitals.

Government.

The American Federal Government is a genuine democracy, admirable for the simplicity and harmony of its principles, and supposed by many to produce a greater amount of public good and private happiness than any political institution that ever existed. Its establishment was an experiment which was deemed doubtful and hazardous, even by the enlightened men who were its founders; but, to use the words of Mr Monroe, "it has succeeded beyond any calculation that could have been formed of any human institution;" and it now exhibits a model in the science of government, which approaches more nearly to ideal perfection than statesmen or sages had dreamed of.

The legislative power is vested in a Congress, consisting of a Senate and House of Representatives. The senate is composed of two members from each State, chosen for six years, by the respective State legislatures, and the seats of one-third are vacated every two years. A Senator must be thirty years of age, an inhabitant of the State for which he is chosen, and he must have been a citizen of the United States for nine years. The members of the House of Representatives are chosen every second year by the people, in the proportion of 1 for every 40,000 inhabitants, excluding the Indians, and two-fifths of the people of colour. The electors being the same as for the most numerous branch of the State legislature, the right of suffrage may be described as universal. A representative must be an inhabitant of the State for which he is chosen, of twenty-five years of age, and he must have been seven years a citizen

* Warden, III. 402, &c. Nile's *Register*, 16th and 30th March 1822, and American Papers.

of the United States. No law can be passed without the concurrence of both Houses. When that is obtained, it is presented to the President, who, if he approves, signs it; if not, he returns it, with his objections, for the reconsideration of Congress, and it cannot in that case become a law without the concurrence of two-thirds of the members. The executive power is vested in a President, who is elected for four years, by a number of electors chosen for the purpose by the people, distinct from the senators and representatives each State sends to Congress, but equal to them in number. The President must be a native born citizen of the United States, and not under thirty-five years of age. His salary is 25,000 dollars (L.5500) *per annum*.

The Congress has power to impose taxes and duties to pay the debts and provide for the defence of the republic; to borrow money; to regulate commerce; to establish uniform laws of bankruptcy and naturalization; to coin money, and fix the standard of weights and measures; to establish post offices; to constitute tribunals; to declare war, raise and support an army and navy; to call forth the militia; and to provide for organizing, arming, and disciplining it. The President is commander-in-chief of the army, navy, and the militia, when in active service. By and with the advice of the Senate (two-thirds concurring), he makes treaties, and nominates ambassadors, ministers, consuls, and judges.

The Federal Judiciary consists of the Supreme Court (formed of a chief judge and six associate judges), which sits at Washington, and a District Court in each State, in which one judge sits. The chief judge has 4000 dollars a year, an associate judge 3500, and a district judge from 800 to 2000. The Supreme Court, deriving its authority from the Constitution, is not bound by the proceedings of the legislature farther than they are consistent with that charter. It has, accordingly, set aside several acts of the State legislatures, and even of Congress itself, on the ground that they contravened an express provision of the Constitution, by annulling or impairing the validity of contracts. The laws of the United States are substantially the same with the laws of England, but differently modified in each State by causes springing out of the physical, moral, and political situation of the people.

United States.

There is no national church in the United States; each congregation pays its own minister, and each sect regulates its own concerns. Notwithstanding this, wherever the population is dense, the means of religious instruction are as ample as in any country in Europe. It is computed that there are above 8000 churches, or religious societies, of which about 3000 belong to the Baptists, 2000 to the Methodists, 1200 to the Congregationalists, 900 to the Presbyterians, 600 to the Episcopalians, and a small number to the Catholics, Dutch Lutherans, Universalists, and other sects.

(B. B. B.)

VACCINATION.

The *Encyclopædia* contains no separate article on the subject of Vaccination; but *Small-pox*, in the article Medicine (224), is concluded, with a notice of its introduction. We now propose to give a condensed view of the subject, and of the present state of medical opinion on the merits of Vaccination.

On the 14th of May 1796, Edward Jenner, a physician in Berkeley, near Gloucester, first applied to the arm of a healthy boy of eight years, by means of two superficial incisions, the morbid fluid secreted by a sore on the hand of a dairy-maid, who had contracted Cow-pock from the udders of her master's cows. The seventh day after the operation he had uneasiness in the arm-pit; on the ninth, became chill, had headache, lost appetite, was otherwise indisposed, and spent a restless night; but the following day, was free from complaint. Of the appearances of the local sore, we have no particular information, but that it resembled a bluish pustule, was surrounded by an erysipelatous or red circle, and afterwards formed scabs and eschars without producing other inconvenience. The object of this operation, which was chiefly experimental, was to ascertain the degree of immunity from small-pox contagion thus obtained; and on the 1st of July, therefore, variolous matter was inserted by inoculation, but without being attended with the usual disease; and when this was repeated some months after, the same effect was observed. Further inquiry was prevented, in consequence of the disease disappearing till the spring of 1798, when it once more made its appearance among the dairies of Gloucestershire. On the 16th of March, a child of five and a half years was inoculated with matter taken from the teat of an infected cow. On the 6th day after the operation, he was unwell, and vomited; but on the 8th appeared to be in his usual health. The progress of the local vesicle was similar to that of the former case, except in the absence of the livid or bluish tint observed. On the 28th of March, the disease was transferred from the arm of this patient to that of William Pead, a boy of eight, with the usual appearances, and especially the red circle, quite similar to that which is observed after variolous inoculation. To this redness Dr Jenner first applied the term *areola*. From the fluid produced in this case, several patients, both young and adult, were infected, and in all, the phenomena appear to have been pretty uniform; or, at least, with deviations so trifling, that they do not require particular notice. From the previous conclusions derived from persons who had been affected with cow-pox, and who resisted the variolous action, it might be presumed to be unnecessary to try how far those who had been artificially subjected to cow-pock could resist small-pox. To render his conclusions more certain, however, Dr Jenner tried it without effect on his first vaccinated patient; and with the second and last cases, his nephew was equally unsuccessful.

Such were the first trials of the effect of vaccine fluid on the human subject; and so far as they were carried by Dr Jenner, the results appeared to warrant the main conclusion, that the process of vaccination renders the human body unsusceptible of being acted on by the infection of small-pox. We must not omit to remark, however, that the *Inquiry* of Dr Jenner shows that he had formed, in the year 1798, no very distinct idea of the nature and phenomena of the vaccine disease, or, at most, that he imagined it to be identical with small-pox. It is evident, that, in his early researches, Dr Jenner believed that the origin of small-pox could be traced to the heel of the horse; and that though cow-pox was a disease transmitted from the horse, and modified by the system of the cow, it was *specially* identical with, or allied to *variola*, and differed in variety only. On this principle, he applied to it the denomination of *variolæ vaccinæ*; and it is obvious that he was confirmed in this opinion by observing, that a person who had suffered the vaccine disease is not liable to be affected with small-pox contagion.

The singular facts announced in the *Inquiry*, and their more extraordinary application, recommended by Dr Jenner, attracted much attention; and shortly after its publication, Dr Pearson of St George's Hospital commenced an investigation, in which he collected many facts tending to render its history more complete, and to demonstrate its power in enabling the human body to resist the contagion of small-pox. In one point only did he disagree with Dr Jenner,—the origin of the cow-pox from the heel of the horse; in denying which, he was supported by the arguments of Dr Parr, and the experiments of Mr Simmons of Manchester.

Dr Pearson's examination of this subject was followed at no long time with *Further Observations* by Dr Jenner, the chief purpose of which was to confirm the conclusions delivered in the *Inquiry*, and to establish the leading fact, that vaccination renders the human system unsusceptible of small-pox. As some cases had come to light of this disease occurring in the persons of those who had undergone the vaccine disease, Dr Jenner, by ascribing these to a *spurious form* of cow-pock, conceived he had removed any exception to the truth or general accuracy of his doctrine. Of the spurious form, he conceived there were four sources: The 1st, From pustules on the nipples or udder of the cow, without specific virus. 2d, From matter, which, though originally specific, had undergone decomposition. 3d, From an ulcer proceeding from the genuine disease, but at an advanced stage. 4th, From matter generated by the human skin, after contact with peculiar morbid matter, formed in the system of a horse. These various positions Dr Jenner illustrated or proved by arguments, either direct or analogical, derived chiefly from similar phenomena, exhibited in the progress of variolous poison. Of these arguments, the most import-

ant are those which relate to differences or variations induced in the genuine poison by elementary decomposition, or by the process of ulceration, after the period of the proper lymph was passed. The propriety of admitting the 4th cause as a source of ineffectual vaccination is intimately connected with the origin assigned to cow-pox by Dr Jenner; for if a modifying effect on equine matter be assigned to the udder, it is impossible to suppose that the former can have a genuine influence on the human constitution, or on the small-pox.

The interest excited by the singular facts disclosed in Dr Jenner's writings, with the confirmation which they derived from Dr Pearson's inquiry, quickly gave rise to the wish of bringing the truth of the doctrines thus advanced to the test of experiment; and men were eager to ascertain what practical advantage was likely to result from the introduction of cow-pox artificially excited, and the substitution of a mild disease, derived from a brute animal, for a human malady, which, even in the most favourable circumstances, was liable to be attended with much danger. The merit of this practical application was reserved for Dr Woodville, who, in January 1799, introduced into the Small-pox Hospital of which he had the charge, vaccine matter derived from the milk-cows in Gray's Inn Lane. On the 21st January 1799, Dr Woodville applied, by a single puncture, to the arms of seven persons, matter in a *purulent state,* obtained from the teats of a cow labouring under the disease; and on the 24th he infected three persons with vaccine matter taken from the sores of Sarah Rice, a young woman who had contracted the disease in the course of milking. From these two sources, this physician affected 600 persons, of various ages, with the vaccine disease; of whom the circumstances of 200 are recorded in the *Reports* of his practice. In most of these patients, inoculation of small-pox matter was performed at various periods after the application of the vaccine disease, with a view to ascertain the genuine power of the latter, and to discover what influence it could exercise in deranging or modifying the progress of the variolous disease. The general result of these experimental cases may be given in the following terms: 1st, In about three-fifths of the whole number, the operation was followed, at intervals of various length, by an eruption of pustules, more or less numerous, over the cutaneous surface. (P. 151.) In one case, in which these pustular eruptions appeared about the seventh day, and was attended with convulsive motions, death took place on the eleventh day after insertion of matter. (P. 149.) 2d, In persons on whom vaccine matter and variolous matter are inserted at different arms, but at the same time, the local affections resulting from each application preserved their characteristic appearances through the whole course of the disease. (P. 139.) 3d, When the two fluids (variolous and vaccine) are rubbed together, and inserted by a lancet dipped into the mixture, sometimes the vaccine pock, sometimes a variolous pustule, has been produced, the respective characteristics being in either case retained throughout; and in some rare instances, both diseases are thus produced. (P. 104.) 4th, If inoculation be performed alternately with variolous and with vaccine matter every day till fever take place, both inoculations make progress; and as soon as the whole system is disordered, they appear to be all equally advanced in maturation. (P. 145.)

It cannot now be doubted, that, though the experiments of Dr Woodville have thrown much light on the nature of the vaccine disease, and on its true influence over the poison of Small-pox, yet they were conducted without due regard to the legitimate mode of ascertaining the truth. 1st, The patients on whom Dr Woodville operated were exposed to the atmosphere of a small-pox hospital, where, of all other places, the air was most likely to be thoroughly impregnated with variolous effluvia. 2d, In the greater number of the patients vaccinated by this physician, inoculation with variolous matter was performed at a period a great deal too early to ascertain the counteracting force of the vaccine disease. 3d, It is doubtful whether, in his selection of vaccine matter, he chose the proper period; for he informs us that the matter was taken from the animal in a *purulent state,* which we now know is very unfavourable to the success of the vaccinating process. (Jenner, p. 113.) 4th, Dr Woodville formed a very erroneous notion of the nature and distinctive characters of the vaccine and variolous diseases; not only in considering, like Dr Jenner, " the vaccine *variolæ*, and the human *variolæ*, to be only varieties of the same disease, rather than distinct species" (p. 152, 153); but in the further error of supposing Cow-pock capable of exciting a general affection of the skin. Our more perfect knowledge of Cow-pock has shown, that its *action on the skin* is confined to those spots only to which it is applied, and that it never hitherto has been known to produce general eruptions similar to itself. This error is intimately connected with another committed by Dr Woodville, in believing cow-pox capable of communication by effluvia, or by any other manner than that of absolute contact.*

The results of Dr Woodville's experiments, so different from those obtained by Dr Jenner, were communicated to this gentleman at first apparently in a private manner (p. 129); and, in order to submit the mattert o a fair trial, London vaccine fluid was transmitted to Dr Jenner, who inoculated several persons, (twenty,—eighteen at the manufactory, two previously, p. 133), without any other difference of effect than a greater degree of local inflammation, and with an eruption of a few red spots, which quickly disappeared without maturating.

It was in a subsequent publication, however, that Dr Jenner undertook the task of examining the experiments of Dr Woodville, and showing the circumstances from which the different results proceeded. The anomalous appearances he here ascribed to the action of variolous matter which had crept into the constitution with the vaccine; 1st, Because a great

* Jenner, p. 86. *Further Observations.* Pearson, p. 50, Proposition VI.

number of the persons vaccinated by Dr Woodville were inoculated on the 3d or 5th day with variolous matter; 2d, Because, in the Gloucestershire dairies, where cow-pox had been known time out of mind, no pustular eruptions had ever been known to appear on the general cutaneous surface; and 3d, Because, though the proportion of pustular cases was at first 3 out of 5, they afterwards diminished so much, that of the last 100 persons inoculated, only seven had pustular eruptions.

To bring this matter to a more satisfactory determination, Dr Jenner procured fluid from an affected cow belonging to a farmer in Kentish Town, and transmitted it to Dr Marshall, who was then extensively engaged in vaccination in Gloucestershire. Under his care 423 persons had undergone, in the course of some weeks, the process of vaccination; and of this number it appears that 127 were infected with the matter sent by Dr Jenner from London; yet Dr Marshall positively states, that neither in the first set of cases, nor in those thus vaccinated, had any pustular eruption occurred, or been observed. (P. 158, 159.) In one case only did a pustule appear in the elbow of the inoculated arm, and it maturated. The same result was obtained in the vaccinations conducted by Dr Jenner personally, and in those by his relation, Mr Henry Jenner. (P. 162.) From these facts, therefore, Dr Jenner concluded, that the vaccine matter obtained from an animal reared in the neighbourhood of London was not different, at least in its effects, from that which was obtained from animals affected with the disease in Gloucestershire. It is proper to notice, however, that Dr Jenner acknowledged that some of his correspondents had mentioned the appearance of eruptions at the commencement of their vaccinating operations; but "in these cases," he remarks, "the matter was derived from the original stock at the small-pox Hospital."

Another point in this inquiry, viz. the immunity from subsequent small-pox afforded by vaccination, came under the investigation of Dr Jenner at this period. Although the evidence upon this point had been already conclusive, yet, as various facts were constantly coming to the knowledge of Dr Jenner to prove the protecting power of vaccination, and its influence in counteracting small-pox, even when the system is under variolous action, he published several of these proofs, in order to show the true power of the vaccine disease. These cases are in every respect similar to many others which have since occurred, and it is unnecessary to bestow further notice on them. Shortly after, a second Tract appeared from Dr Woodville; and though his object was to refute the assertion of Dr Jenner regarding the adulteration of the vaccine matter of the Small-pox Hospital in London, his testimony was of the utmost advantage to the anti-variolous power of vaccination. It will be remembered, that, towards the conclusion of Dr Woodville's vaccinations, the varioloid or pustular eruptions which had been so frequent at the beginning, began gradually to diminish, and finally almost to disappear; and in the further prosecution of this physician's experimental investigation, we find that these eruptions were found almost never to succeed the process of vaccination. In his *Observations on the Cow-pox,* which appeared in July 1800, many important facts were disclosed, which tended directly to unfold the true properties of the vaccine disease, and the relation which subsists between its action and that of small-pox. It is unnecessary, at this distance of time, to enter into the merits of the charge which Dr Woodville conceived Dr Jenner brought against the vaccine matter of the Small-pox Hospital, and of the mode in which Dr Woodville attempted to repel it; and as we do not conceive it tended, in the slightest degree, to illustrate the question, of the cause of the pustular appearances after vaccination in that Hospital, it may be passed over in silence. The more important and not less interesting subjects of Dr Woodville's pamphlet were the fact of the disappearance of these pustular eruptions, and the circumstances under which they disappeared. 1. The vaccine matter of the Small-pox Hospital, after which pustular eruptions had so generally appeared, was employed in two situations in the country, in vaccinating more than 1000 persons, in two of whom only did any pustules, resembling those of small-pox, appear. 2. Though Dr Woodville denied adulteration of the vaccine matter with matter of small-pox, he was, however, obliged to admit, that the cases of vaccination in the Hospital "had been, and still continued to be, influenced by some adventitious cause, independent of cow-pox." This was proved by the results of vaccination practised in the hospital by matter obtained from many different animals: by the results of vaccination practised on persons at their own houses, in various districts of London, by Dr Woodville and other medical gentlemen who employed the matter from the same stock; and more decidedly by the result of vaccination practised on three patients at Hospital, with matter obtained from the same cow, from which Dr Jenner took the matter employed in the vaccinations of Dr Marshall. In one of these patients no fewer than 100 varioloid pustules appeared; and other instances, equally conclusive, appear to have taken place. 3. Among many children residing in various parts of London, to whom Dr Woodville transferred the disease, through the medium of the Hospital matter, no instance of maturated pustules had occurred during the twelve months succeeding to the introduction of the practice. 4. The pustular eruptions which had been so common after vaccination, at the early period of the practice, became much less frequent. Of 310 cases of vaccination, after the publication of the first *Reports*, 39 were attended with pustular eruptions in the following order:—In the first 100, 19; in the second 100, 13; and in the last 110, only 7; and at a later period they appeared in the proportion of 3 or 4 only in the 100.

From these various facts, Dr Woodville very justly drew the inference, that the cases vaccinated at the hospital differed from those vaccinated elsewhere, in being placed in the centre of a variolated atmosphere, to the operation of which the pustular eruptions were to be ascribed. In forming this conclusion, however, he committed the singular paralogism of supposing that the cow-pock *excited* these pustules, or was, in

other words, the direct cause of the varioloid disease; and he, therefore, imagined that the variolated atmosphere of the Hospital, the existence of which he willingly admitted, was only a co-operating cause. It is obvious that this extraordinary doctrine owed its birth to the previous opinion which, we have already remarked, he formed of the nature of the vaccine disease,—that it was not confined to the spot to which lymph is applied, but was capable of extending its action over the whole cutaneous surface. Had Dr Woodville not allowed himself to be misled by this erroneous principle, there is a strong presumption, from the language in which he expresses himself, that he would have arrived at the true conclusion which recent and accurate observation have at length succeeded in establishing.

When the facts above noticed are considered, we conceive it will not be difficult for our readers, if they keep in mind the points originally ascertained by Dr Jenner, respecting the local action of the vaccine disease, and the necessity of its being communicated by application of its proper fluid, to comprehend, that the pustular eruptions over the cutaneous surface of the vaccinated were not excited, as Dr Woodville concluded, by cow-pock, nor arose, as Dr Jenner suspected, from mixture of variolous matter with vaccine, but were the immediate results of the variolous atmosphere in which the individuals were placed. The different degree in which they appeared in the early and more recent period of Dr Woodville's vaccinations, will form no valid objection to this conclusion, when it is remembered, that the frequency of pustular eruptions in the first vaccinations, depended on the abundance of variolous effluvia necessarily existing in a small-pox Hospital, or the saturation of its air with this matter;—while their subsequent rarity was the effect of its gradual diminution by the division or diminution of its cause, and of its final extinction by the substitution of another disease. That admixture of variolous matter had not taken place, there is every reason to conclude; as we know, from the experiments of Dr Woodville, that it is impossible to produce in this manner a mixed or neutral disease, but that each preserves its distinctive and appropriate characters. The post-vaccine pustular eruptions should have suggested another conclusion,—that the vaccine disease does not entirely extinguish the variolous, or prevent its appearance, but renders it milder, less tedious, and, to a certainty, destroys the chance of its fatality. That this conclusion escaped Dr Woodville is by no means wonderful, especially when it is remembered, that the general belief of the profession was, that a second attack of small-pox was an occurrence so rare, as to be considered next to impossible. "Happy is it for mankind," says Dr Jenner, "that the appearance of the small-pox a second time on the same person beyond a trivial extent, is so extremely rare, that it is looked upon as a phenomenon. Indeed, since the publication of Dr Heberden's paper on the *Varicellæ* or chicken-pox, the idea of such an occurrence, in deference to authority so truly respectable, has been generally relinquished." It is worthy of remark, also, that Dr Woodville not only admitted this inference in its fullest extent, but applied it, in the same unlimited construction, to the immunity afforded by vaccination against the variolous disease. "This circumstance, then," says he, (that is, the immunity afforded by cow-pox), "appears to be as much a general law of the system, as that a person having had the small-pox, is thereby rendered unsusceptible of receiving the disease a second time." (*Reports*, 155.) On this subject it is only necessary to remark, that Dr Thomson of Edinburgh has shown, in the most convincing manner, that the non-recurrence of small-pox has been admitted on far too slender grounds; and that the writings of physicians contain sufficient evidence, that small-pox may occur at least twice, if not three times, in the person of the same individual. Had this important proposition been known, or admitted to its just extent, at the period when vaccination was introduced, there is reason to believe, that the appearance of pustules on the persons of those who had been vaccinated, would not have occasioned so much perplexity to the friends of the practice, or triumph to its enemies, and that its true merit would have been more justly, and not less quickly appreciated.

During the progress of Dr Woodville's experimental inquiries, the merits of vaccination began to be understood, and the practice had been coming into general and extensive use, both in London and in the more remote counties of England. The publication of Dr Woodville's second Tract may be regarded as marking the epoch of its general admission, and announcing the adoption of it in Public Charities, and in the practice of the most eminent surgeons. The united efforts of Drs Pearson, Lettsom, MM. Moore, Ring, &c. and other philanthropic or professional individuals, contributed powerfully to its general introduction; and though opposition was at first shown, the more candid and intelligent part of the profession at length admitted the advantages of vaccination over artificial variolation. It is unnecessary to bestow any notice on the objections which were urged by writers of a certain class, and which, as they were founded on prejudice have now sunk into a well merited oblivion. The efficacy of vaccination, as an anti-variolous agent, was, indeed, so generally admitted, and the practice was so widely introduced, that its benefits were extended, in the course of a few months, to many thousand persons, in different towns of the kingdom; and were conveyed by different channels to Paris, to Vienna, to most of our colonies, and to the United States of America. In the meantime, the impression created at first by the appearance of pustules in the vaccinations of Pearson, Woodville, Ring, Dunning, Goldson, and others, seemed to have worn off completely, or to have been forgotten; and the great bulk both of the profession and of the public considered the occurrence of small-pox eruptions, after vaccination, either impossible or so rare as to be regarded as a physiological anomaly. The general credence of this maxim did not arise from the complete absence of pustular eruptions after vaccination, as we shall see, but evidently depended on the idea of the distinctive nature of chicken-pox, or the inaccurate notions of small-pox itself then prevalent; and also on the great

expectations formed of the powers of the vaccine disease in counteracting or extinguishing the poison of small-pox.

The truth of these assertions is abundantly confirmed by the subsequent history of vaccination, and of small-pox eruptions occurring either sporadically or epidemically in various parts of the country. We have already seen, that Dr Jenner was led to infer the absolute immunity from small-pox conferred by the process of vaccination, and to consider the vaccine disease so similar to small-pox, that when the human body had undergone the former, it was no longer liable to attacks of the latter. This doctrine was admitted by many professional persons in terms much more unlimited, if possible, than those in which it had been understood, even by its first promulgator. Dr Jenner was, indeed, inclined to qualify it in some degree; but the professed partizans of vaccination, from a well-meant idea, perhaps, that it would weaken public confidence, and render the adoption of vaccination less easy than was consistent with public safety, opposed every approach to such an opinion, and defended strenuously the anti-variolous properties of the vaccine disease.

It is scarcely necessary to mention here, that, since the time of Dr Heberden, a vesicular, or vesiculo-pustular disease, not unlike small-pox in its local appearances and constitutional symptoms, had been distinguished from it as a separate affection under the name of *Chicken-pox*. Almost all the instances of pustular or small pox-like eruptions which were observed after vaccination, were referred to the head of chicken-pox; or if they were not sufficiently similar to this disease, to be referred to it, they were admitted to be small-pox, but occurring only in persons on whom vaccination had been imperfect in action, or improperly performed. In other instances, the appearances of the eruption were so fallacious, or the ideas of the observers so little precise, that of those who saw them some contended that they were chicken-pox, and others small-pox.

Although cases were not unfrequent in which practitioners of experience and knowledge were obliged to admit the occurrence of small-pox, in the persons of those who had undergone vaccination, Dr Willan appears to have been the first who had courage and patience sufficient to examine the matter coolly, and to show the exact weight of evidence by which it was supported. In the fourth section of his interesting treatise on *Vaccine Inoculation*, this physician has collected several cases which occurred to himself, or within his own personal observation, and referred to those collected by authors since the introduction of the practice of vaccination. As many of these were thought by several physicians and surgeons to have been chicken-pox, and as this indicated want of precision in the characteristics of the disease, Dr Willan, in his seventh section, gave an account of those marks by which he conceived chicken-pox in three different forms could be recognised. And it is by no means unimportant to observe, that the distinctions which Dr Willan established among the various forms of cutaneous inflammation, and the precision with which he expected the eruptive diseases to observe those characters, prevented him from taking those general and more just views of post-vaccine small-pox in which physicians have since coincided. Little change, therefore, appears to have taken place in the opinions of professional men, farther than to admit the occurrence of chicken-pox, and of a modified small-pox after vaccination; or, if the appearances were too strong for this construction, to consider the vaccination as imperfect and ineffectual. Such, in general, was the tenor of the *Reports of the Vaccine Institutions*, of our various public charities, and in some instances of scientific Colleges; and so unanimous and decided was the language of those bodies, that individuals were unable to form their own opinions on objects of daily observation, or were prevented from expressing them by the fear of being regarded as either incapable of observing, or unable to communicate the genuine and perfect form of the vaccine disease; or, in short, as enemies to a practice, the pious object of which was to counteract a foul and fatal disease, and to increase the probable chances of human life.

The publication of these *Reports* did not, however, cause the complete extinction of post-vaccine small-pox, or prevent the appearance of the disease; and cases continued to occur even after the process of vaccination was admitted to be satisfactory, and in the observations of physicians, whose knowledge and experience gave no ground for doubting the fact. It cannot be expected, that all these cases have been published, or that their full extent can now be ascertained; for it is easy to see, that they would be often disregarded, and sometimes studiously concealed. To understand, however, the merits of vaccination, and its influence in controlling small-pox, sporadic or epidemic, it is indispensably necessary, for the unbiassed inquirer, to be aware of the evidence which may be obtained from the cases of variolous or varioloid eruptions in the persons of the vaccinated already recorded. It was to Dr Thomson of Edinburgh that was reserved the merit of ascertaining the true powers of vaccination, and of placing in a just point of view the benefits conferred on mankind by the introduction of the practice. The cases of pustular eruption, in the persons of the vaccinated, were scattered in various works, their evidence was neglected and overlooked, and the inferences which they tended to establish were not understood, or they were disregarded. It was only by comparison with those afforded by subsequent observation, that real advantage could be derived from them. An opportunity for this investigation occurred in 1816, when small-pox began to appear in one or two points of the country, and eventually spread over a considerable extent. Had the appearance of small-pox been confined to one or two towns or villages, it is not unlikely that they might have been viewed in the same indifferent light in which they had been since 1800, and that they would have continued to give rise to the same doubts, and similar imperfect explanations, which they had previously done. Appearing, however, as they did in many different points of the Island, successively or simultaneously, and, as was afterwards learnt, in several countries of Europe, the public mind became alarmed, professional curiosity was

awakened, and physicians resumed the task of investigating a disease which, it had been fondly but prematurely hoped, vaccination would render practically unknown. In the year 1816, accounts of small-pox,—occurring in persons of all kinds, those exposed to contagion and those not exposed,—the vaccinated, the unvaccinated, the imperfectly vaccinated,—and even in those who had previously undergone the disease, began to be transmitted to the various periodical publications; and during the four subsequent years, the epidemic continued to appear or subside at intervals, and to furnish matter for the observation and reasoning of physicians, whether vaccinators or inoculators. In Edinburgh, and various parts of Scotland, they prevailed to a very considerable extent, attended with a mortality of 1 in 4 to the unvaccinated and unvariolated, and affecting the vaccinated in the rate of 1 to 2 nearly. Though the individual cases have been observed and collected by many different professional gentlemen, it is to Dr Thomson almost entirely that we owe the thorough investigation which the subject has at length undergone, and from whose researches have been derived the certain and satisfactory results which we now possess. This physician, equally distinguised by acuteness of reasoning, sound judgment, and habits of accurate observation, examined personally the whole of the cases almost that occurred in Edinburgh and its vicinity; and where the distance rendered personal examination inconvenient, procured, from intelligent correspondents, correct accounts of the phenomena. It was in a letter addressed to the Editor of the *Medical and Surgical Journal* in September 1818, that Dr Thomson first expressed his opinion of the incorrectness of the prevalent doctrines on the effects of the vaccine disease, and of the common doctrines on small-pox, chicken-pox, and modified small-pox, with which these opinions were intimately connected.

In consequence of the publication of this letter, and a subsequent one containing a series of queries tending to illustrate or ascertain the doubtful points of the subject, a great body of evidence was in a short time collected, and in various forms laid before the profession. The results, with those of Dr Thomson's very extended observation of the disease, may be found in the two works which he has recently published; and in which he has canvassed, with the greatest judgment, and in the most liberal manner, all the problematical and assumed points of the subject.

The circumstances, however, which merit particular attention, in this recent epidemic, are the strong confirmation of the truth of many of the earliest observations since the introduction of vaccination; and especially of those views which we have already shown, the experimental inquiry of Dr Woodville, if properly understood, would have suggested. The varioloid disease, at least in Edinburgh and its vicinity, and so far as can be discovered, throughout Scotland, occurred in three classes of persons; those who had undergone neither small-pox nor cow-pox, those who passed through small-pox, and those who had undergone, in a satisfactory manner, the process of vaccination.

In these several classes of patients, it was found that the different forms of varioloid eruptions described as pure small-pox, modified small-pox, and chicken-pox, co-existed during the epidemic, and were capable of producing each other. It was observed, for example, that individuals who, after vaccination, presented eruptions, termed modified small-pox or chicken-pox, were capable of communicating to those who had neither undergone vaccination, nor had been affected with small-pox, an eruptive disease which could not be distinguished by competent judges from small-pox. (Thomson, *Varioloid Disease*, p. 45, and p. 207.) It was also found, that the same contagion or the same infecting source, produced cases of coherent or confluent small-pox in the unprotected; and cases of chicken-pox, or modified small-pox in the vaccinated, or even in persons who had many years before passed through small-pox. The obvious conclusion from these facts is, that if small-pox and its modifications, and chicken-pox be admitted to derive their origin from a contagious source, that contagion must be one and the same for all; and that whatever opinion be formed as to the nosological differences of small-pox and chicken-pox, as pustular or vesicular eruptions, it must be granted, that they spring from the same generating cause; and that the variations in appearance depend on something totally unconnected with the contagious agent which causes their formation. There is no means of accounting for this relation of diseases, Dr Thomson has justly remarked, unless in supposing two contagious causes, specifically distinct, existing at the same time, and in the same place, and producing their respective effects on the persons of those exposed. But, independent of the general improbability of this doctrine, it might be easily shown, that of two such distinct contagious causes as we have supposed, not only would one or other have produced its characteristic effects on a much greater proportion of the community; but these effects could not possibly have been so frequently interchanged, or so uniformly have appeared in place of each other, as the experience of the recent epidemic has shown. To render this point, which is liable to be misunderstood, especially by our general readers, more obvious and intelligible, let it be supposed, as was done after the time of the elder Heberden, that chicken-pox arose from one morbid cause, and small-pox from another, utterly different; and let it also be admitted, that both contagions are occasionally found to appear in a community epidemically; then it must follow, that the disease which depends on chicken-pox contagion ought at all times, and in all cases, to preserve distinctive characters, and that small-pox should likewise preserve the same unvarying peculiarity of appearance. No approach of characteristic features, much less complete interchange, ought to take place; and the phenomena of chicken-pox ought to be as distinct from those of small-pox, as they are from those of plague, of itch, or of leprosy. These results, however, which unquestionably flow directly from the admission which we have made of distinct contagious agents, were completely contradicted by every thing observed in the variolous epidemic of 1817-

18, and the subsequent years; and it is impossible to resist or deny the conclusion, that small-pox, chicken-pox, and modified small-pox, owe their birth to the same source, are children of the same parent, and members of the same family.

It may be expected, since we adopt the conclusions to which the modesty and good sense of Dr Thomson induce him to apply the name of *hypothesis* only, that we ought to prove, by direct arguments, the nosological error committed by Dr Heberden, in separating chicken-pox as a distinct genus from small-pox. To this we reply, that it is not by direct arguments that the point can be proved; for, without subjecting to strict scrutiny the characters on which Dr Heberden assigned a separate place to chicken pox, it is now agreed that the minute distinctions of Dr Willan completely failed in establishing a satisfactory difference in the generating causes of chicken-pox and small-pox. Had Dr Willan indeed given a due degree of weight to the fact which he states in the very outset of his 7th section, that he had seen since 1800 no fewer than 74 cases of varicella, which were by many persons deemed small-pox after vaccination, and the remarkable counterpart of this fact, that the eruptions described in his 4th section were at first regarded as chicken-pox by several physicians and surgeons, he must have been convinced of the impossibility of establishing a difference between these diseases on no other ground than that of their vesicular or pustular character. We adhere in this case to the acknowledged maxim in philosophical inquiry, to admit no more causes than are adequate to account for the effect; and while we allow the excellence of the distinctions introduced by Dr Willan as mere terms for characteristic appearances, we deny the inference that has been drawn, that these are adequate to establish a nosological difference. It is, indeed, with those who contend for the specific or generic difference of small-pox and chicken-pox, that the task of proving this rests; and it is incumbent on them to bring forward more substantial proofs and arguments than those on which the distinction has been admitted, and which are undoubtedly inconclusive.

Though the hypothesis to which we have here adverted, evidently does not require to be supported by different arguments derived from other quarters, yet it is equally due to the merit of Dr Thomson, and to that of other physicians, whose observations have led them to similar researches, to remark, that the identical origin of small-pox and chicken-pox is an opinion at length adopted by others, both in this country and on the Continent. Our limits prevent us from entering largely or particularly into this division of our subject; but we must not leave it, without adverting to the opinions expressed by MM. Berard and De Lavit of Montpellier, and Dr Hodenpyl of Rotterdam. Small-pox prevailed epidemically in the former city in 1816, and in the latter, and various parts of Holland, in 1817 and 1818; and in both situations, not only were chicken-pox at the same time extensively prevalent, but the phenomena of both diseases were found to be frequently and generally interchanged; and they were, in other respects, so similar to those observed in Edinburgh and various parts of Scotland, that the conclusions which we have above noticed were irresistible. It is interesting to observe, not only as a confirmation of the accuracy of Dr Thomson's views, but as an example of different observers, unconsciously and unknown to each other, forming the same conclusions from similar researches, that MM. Berard and De Lavit were led to announce, in 1818, at Montpellier, an opinion which Dr Thomson first published in September 1818, at Edinburgh; and that Dr Hodenpyl of Rotterdam, in the course of the same year, was led to express his opinion, that chicken-pox was the primitive form of small-pox, and could be shown to originate from the same parent stock.

The view which the hypothesis of Dr Thomson enables us to take of varioloid and varicellous eruptions, and of the relation in which they stand to the vaccine disease, suggests a more satisfactory explanation of the phenomena which these eruptions present, and of the *sequences*, as we may name them, which they observe, than either denying the anti-variolous efficacy of vaccination, or supposing it imperfect, or improperly performed; or, indeed, than any other explanation hitherto adopted by physicians. It has been a prevalent error with medical observers to attach a degree of mathematical precision to the phenomena of eruptive diseases, and especially to those of the several forms of variolous or varicellous eruptions; and to imagine that their appearance and effects in the human body were regulated by laws of the utmost precision. The mixture of truth and of error exhibited in this doctrine is the reason of its admission without question, and its propagation without resistance. For while it is certain that extended observation proves that small-pox may affect the same individual more frequently than once, and that its first occurrence by no means secures the individual from a second attack, it is undeniable that the maxim is so far correct in general terms, that the disease is rarely known to appear twice with the very same characters, or with the same severity in the same individual. While, therefore, the first appearance of the disease does effect some change in the susceptibility of the frame to a second attack, it is obvious that this change is neither so marked nor so uniform, nor so absolute as the opinions of physicians had hitherto represented it to be. (Thomson's *Varioloid Epidemic*, p. 201.) It is precisely this error which has given rise to mistakes so general on the anti-variolous power of vaccination. It was the same mode of thinking that led the more zealous partizans of vaccination to expect a form of action more absolute and determinate, and an immunity more complete than the laws of organic motions ever sanctioned. It may be urged, indeed, that to predicate what the laws of organic motions are, or what they sanction, is a mere *petitio principii*, a sort of assumed principle, unless we adduce facts or arguments to prove what we advance; but is it to be doubted, that the actions of living bodies, and the influence exercised on living objects by exterior agents, are not regulated by laws mathematically exact? Has the most sedulous observer ever been able to trace or to demonstrate that certainty of action, or regularity of effect, which is exem-

plified in matter endowed with properties merely physical? Has attentive observation of the phenomena of living bodies, and, above all, of those of the human frame, not shown, that the results of every process are influenced by numerous circumstances, and modified by causes too complicated to allow their operation to be appreciated? Such, we may now conclude, has it been with the practical application of the vaccine disease, and such will it be with every measure which is adopted in medicine, with too little regard to the character of those objects on which the physician has to operate.

It must now be obvious, that vaccination is not the positive and exact action, which it was thought to be at the moment of its introduction; and, that it does not effect on the human body that absolute change which it was originally represented to do. That it does effect a change of some kind must be inferred, not only from the phenomena of those forms of small-pox which occur in the persons of the vaccinated, but also, in a more conspicuous and forcible manner, from the phenomena of vaccination performed a second time on the same individual. The vesicle produced in Mr Bryce's test-vaccination, or even any vesicle thus produced at a period subsequent to the first one is evidently a modified cow-pock (*vaccinella*), and bears the same relation to the first cow-pock, that modified small-pox or chicken-pox bear to the first attack of small-pox.* But the occurrence of this *vaccinelline* vesicle must be regarded as a direct proof that the change is not absolute, but limited; and the occurrence of pustular eruptions, whether variolous or varicellous, in the vaccinated, must be admitted in evidence to establish the same conclusion. It may, indeed, be regarded as the genuine result of extensive observation, conducted in the most accurate manner, that the process of vaccination is not exempted from those uncertainties which have long formed the impediments to exact principles and positive rules in medicine; and that it does not render the human body universally or absolutely unsusceptible of subsequent attacks of small-pox in various degrees of severity.

Nor will the results to which we have cursorily adverted, admit of more easy explanation by the objection which has so often been sought in the interruption or imperfection of the process of vaccination. It is not to be denied that vaccination has been sometimes rendered imperfect by one or other of the ordinary causes, and that it is reasonable to think that persons thus vaccinated are more likely to be subsequently affected with small-pox than those in whom the vaccine process has been regular and complete; but no proof has been afforded that post-vaccine small-pox was confined to those in whom vaccination was imperfect; and in innumerable instances in which small-pox succeeded vaccination, the latter process was ascertained to be as perfect as in those who were not subsequently the subjects of varioloid eruptions. Had there been any force in the circumstance, it was reasonably to be expected that the degree of modification should be in the inverse ratio of the perfection of the vaccine process, and in the direct ratio of the interval between the period of vaccination and the appearance of varioloid disease. No result of this kind has been observed either in the Edinburgh epidemic, or in those described by Mr Cross and MM. Berard and De Lavit, or that of Holland, as described by Hodenpyl; nor has it appeared, that those affected with modified small-pox had been vaccinated with fluid taken at an improper time, or had cutaneous eruptions, or other disturbing causes, to a greater extent than those in whom varioloid eruptions never took place.

The experience of the recent epidemic has amply confirmed the conclusion, that vaccination, though quite regular, and performed in the most satisfactory manner, does not preclude a subsequent attack of small-pox, in one or other of its forms, and does not furnish a positive immunity any more than natural small-pox, or artificial variolation. And it is satisfactory to think that this inference has been substantially admitted by the unbiassed declaration of the Board of the *National Vaccine Establishment*.

But while we are obliged to qualify the doctrines of the original vaccinators with these limitations, it cannot fail to be gratifying, not only to the lovers of truth, but also to the sincere and temperate friends of vaccination, to find that the great practical results are not materially affected; and to know that our experience has shown the benefits of the practice in as strong a point of view as its most sanguine advocates could wish. Though the process of vaccination does not positively prevent a subsequent attack of small-pox, it has been incontestibly proved, that it not only mitigates the severity of such future attacks, but diminishes the chance of their fatality almost to a fraction, or an infinitely small quantity. The clearest method of showing the truth of this proposition is, by contrasting the mortality of cases of secondary small-pox, that is, occurring either after the natural or artificial disease, with the mortality of cases of small-pox occurring after vaccination. According to the observations of Dr Thomson, the proportion of deaths in secondary small-pox, if two infections be admitted, is 1 in 25, and if one infecting source be admitted, 1 in 75 only (*Varioloid Epidemic*, p. 202); but death has taken place in small-pox after vaccination in one only of above 330 cases, which is between $\frac{1}{4}$ and $\frac{1}{5}$, or, in exact terms, $\frac{5}{22}$ less frequently than it occurs in iterated small-pox. If to this statement be added the allowance that must be made for the numbers of the vaccinated who were *not* at all affected with subsequent varioloid eruptions, the rate of post-vaccine eruptions terminating fatally will be reduced to an infinitely small quantity. In the varioloid epidemic described by Mr Cross, at Norwich, of 10,000 vaccinated persons, $329\frac{6}{91}$ were affected with

* See Dr Thomson's remarks at the conclusion of Dr Stoker's *Letter* in No. 77 of *Edin. Med. and Surg. Journal*.

variolous eruptions,* of whom only one case appears to have terminated fatally. The coincidence of this proportion with that given by Dr Thomson induces us to place the greatest confidence in its accuracy; and we feel certain, that if observations be made on future cases, even this proportion will diminish. At present, in estimating the decided superiority of vaccination, in diminishing the chance both of danger and of death from small-pox, two elements must be kept in mind:—1st, That all the vaccinated are not affected with small-pox or varioloid eruptions, and even the proportion of these appears to be smaller than in instances of inoculation, or any other method except natural small-pox;—and, 2dly, That of those so affected, not above one case in 330 terminates unfavourably. These results establish, in the most convincing manner, the powers of the vaccine disease as an antidote to the ravages of small-pox; and cannot fail to prove, to the satisfaction of its most sceptical opponents, that the strong and plausible objections to which the recent epidemic was at first calculated to give rise, have been of no other use than to place the merits of vaccination in a clearer and more forcible point of view.

It is in its power of diminishing the mortality of small-pox, therefore, that the superiority of vaccination consists; and it is on this strong ground only, that its partisans and true friends should defend its general adoption. Let the governors of charitable institutions, the guardians of the poor, the parents of families, and the public at large, be convinced of the facts which we have now stated, and the inferences derived from them, and it cannot be doubted that the practice of vaccination, instead of being opposed, or apprehended as a source of new and disastrous maladies, or ridiculed as a useless and inefficient ceremony, will be dispassionately estimated, and raised to that rank among the benefits of science, to which its happy effects unquestionably entitle it. It is surely superfluous to show the duty incumbent on all ranks to extend vaccination as widely as possible, if for no other reason than to preserve the lives of their relatives during the prevalence of epidemic small-pox,—and to say that, in proportion as vaccination is general, the infection of small-pox must be gradually limited and confined, until it is almost entirely expelled from the habitations of men. There cannot be a doubt, that every variolous epidemic, especially in large cities, is developed much more readily in consequence of the practice of variolous inoculation, or suffering children to be exposed to the infection of natural small-pox; and it is equally certain, that where vaccination is general, the introduction of variolous infection is either difficult, or when introduced, it is disarmed of its gigantic strength.

Two points connected with this subject have given rise to so much speculation, that we must not omit to notice them, however briefly. The introduction of vaccination, and its effects in diminishing the mortality of small-pox, have been naturally supposed by many writers to have a great influence on population, and to increase the numbers of the living at different periods of life. Some have gone so far as to imagine, that in this respect it would operate to an injurious extent, and increase the population of most countries beyond the limits of subsistence; while others have conceived, that an increase of different diseases would be necessarily occasioned by the extirpation of small-pox; and that this would be one of the great means employed by Providence, to keep the rate of population in due proportion to the means of procuring food.

There cannot be a doubt that one of the most salutary effects of the practice of vaccination is to diminish very much the mortality occasioned by small-pox, and consequently to augment, in a considerable degree, the numbers of the community in which it is practised. To understand distinctly, however, in what manner this diminution is operated, it is requisite to show the effect which unresisted small-pox exercises on the population of a community, and for this purpose we employ a familiar example derived from estimates formed in this country. In the year 1795, when the population of Great Britain and Ireland was estimated, according to the returns, at 14,724,000, it was calculated that the numbers annually destroyed by small-pox, according to one estimate, amounted to 34,260, and according to another, to 36,000. If we state it in round numbers at 35,000 as a medium, this mortality amounts to the enormous proportion of 1 in every 420; or, in other words, small-pox destroys annually 1-420th part of the whole population of the country. As it is obvious, that the population can be increased by the number of births only, as it is diminished by the number of deaths, it follows, that to obtain a just notion of the effect of small-pox in diminishing the population, we must deduct this 1-420th part from the numbers which are annually added by births. According to the most correct observations and calculations, it appears, that at the period which we have selected, the proportion of births to the whole population of the country was as 1 to 30, or for every 30 persons in the whole nation, only one is annually added by births. (Malthus, Book II. chap. 9, and *Additions*.) It therefore follows, that as the proportion destroyed by small-pox must be taken out of this annual addition to the numbers of the country, the fraction of $\frac{30}{420}$ or $\frac{1}{14}$ annually, will represent the exact rate at which small-pox retards the increasing numbers of a country, or acts as a positive check on population. It is to be remarked, that the elements on which these calculations are

* Mr Cross nowhere gives this proportion exactly; but it is correctly deduced from the average of his data in the following manner:—Dr Yellowly, from inquiries similar to those of Mr Cross, estimates the vaccinated in Norwich at $\frac{1}{4}$ of the whole population, or 10,000; and of 603 persons under the personal observation of Mr Cross, 200 had small-pox, 91 had been vaccinated, 2 of whom had modified small-pox, and 1 chicken-pox; the remaining 312, who had small-pox formerly, had no subsequent eruption during the epidemic; consequently, we have the following proportional numbers, 91 : 3 : : 10,000 : $329\frac{61}{91}$.

founded, are derived from that period at which it is generally admitted that small-pox inoculation was most favourably conducted, and at which the smallest number of deaths is supposed to have taken place from small-pox, since it first began to prevail as a destructive epidemic among the habitations of men.

We have given this familiar, and we trust quite intelligible view of the influence of small-pox on population, because we fear, if we had attempted to follow the circuitous, but very beautiful and accurate train of analytic calculation, by which Duvillard has investigated the subject, we should have added much to the length of this article, without interesting our general readers, or affording information universally intelligible. This author, who has investigated the matter in the soundest manner, and with the most profound applications of modern analysis, has given formulæ and tables for almost every possible question which the inquiry can suggest. He appears, on the principles which he has adopted, to have made the destructive or depopulating power of small-pox greater even than we have shown it to be. He gives the following results of his analytic investigations, as applied to the population of France. According to the law of mortality, in the natural state, the

		Both sexes and all ages.
Entire population of France is - -		28,763,192
Those already passed through small-pox,	23,212,998	
Those not passed through it are -	5,450,194	
Those that die without passing through it,	667,749	
Those who must have it at some period,	4,782,445	
Those that take it and escape, - -	4,445,041	
Those that die of it,	337,404	that is, 85,685 in the current year.

Now, in the natural state, 85,685 children, add to the population of 28,763,194, only 337,404 individuals, and by immunity from small-pox, they furnish farther 3,492,583, which raises the population to the number of 32,255,776. If such be the influence of vaccination, in increasing the numbers of mankind, it might appear, a conclusion sufficiently natural to imagine, that the population of many nations would increase so rapidly, as to exceed the means of subsistence, and overcrowd the space allotted for occupation. In point of fact, however, notwithstanding the operation of this cause, for at least twenty years, in several countries of Europe and America, the result has not been realized; and, though the nations of Europe were perhaps never so populous as at the present moment, this evidently depends on other causes than that which prevents the mortality of small-pox.

It is a fact which has been said to be ascertained by many respectable observers, that while the destruction occasioned by small-pox has been much diminished, other diseases, equally fatal, have been found to be more prevalent. We will not question the correctness of this observation, or deny it absolutely, but we must have it established on more certain and unquestionable facts and documents before it be admitted. But whether this be the case or not, it is not difficult to see that vaccination cannot possibly render the human race immortal; that children, and adults also, must die of other diseases besides small-pox; and that, as the numbers of a young community are increased by being snatched from one disease, a greater number must be preserved to become a prey to others.

We by no means, however, countenance the opinion that the mortality of other diseases will increase exactly in the ratio in which that of small-pox has been diminished; nor do we believe that this mortality is a necessary result of vaccination. It is found, on the best authority, that a perceptible diminution of mortality in children under ten years has taken place in every situation in which vaccination has been general; and it must therefore be concluded, that the number of individuals living at that age is augmented. It is obvious, however, that, unless we lose sight of the most fixed principles in the theory of population, this will have but a trifling effect in increasing the numbers of mankind, when it is remembered that it is ready to be counteracted by the positive checks to which we already alluded, but especially by the preventive check on which the number of marriages and of births depends.

(See various papers in the 6th, 7th, 8th, 13th, 14th, 15th, 16th, 17th, and 18th Vols. of the *Edinburgh Medical and Surgical Journal;* several articles in the *London Medical and Physical Journal; Observations on Small-pox, &c.* by Dr Monro, Edinburgh, 1818; *Account of the Varioloid Epidemic which has lately prevailed in Edinburgh, and other parts of Scotland, &c.* by Dr Thomson, Lond. 1820; *Historical Sketch of the Opinions entertained by Medical men respecting the varieties and secondary occurrence of Small-pox,* by Dr Thomson, Lond. 1822; *A History of the Variolous Epidemic which occurred in Norwich,* 1819, *and destroyed* 500 *individuals, &c.* by Mr Cross, Lond. 1820; *Essai sur les Anomalies de la Variole et de la Varicelle,* par MM. Berard et De Lavit, Montpellier, 1818; *Select Dissertations on several Subjects in Medical Science,* by Sir Gilbert Blane, Dissert. 10th, p. 334; *History of Vaccination,* by Mr Moore, Lond. 1817; *Correspondence of the Dublin Cow-pock Institution,* published in 1818; *Observations on the Varioloid Disease,* by Dr Stoker, Dublin, 1821.) (U. U. U.)

VAN DIEMAN'S LAND. See the Article Australasia, in this *Supplement.* It appears, from a Statement of the *Receipt and Income* raised in this colony, and of the *Disbursement* thereof, for the last seven years, printed, by Order of the House of Commons, in June 1823, that the former was L.23,915, and the latter L.20,055.

VEGETABLE PHYSIOLOGY.

In the Article Anatomy, Vegetable, of this *Supplement*, we exhibited a view of the structure and forms of vegetables through their several gradations from the seed to the perfect plant. We then observed, that, to accomplish these changes of form, the operation of certain external agents was required, by the aid of which alone the several functions of vegetables could be instituted and maintained. It is to these functions that we have now to direct our attention, —the description of which properly constitutes what is termed the Physiology of plants.

In a subject of such great extent and difficulty, and concerning which so much diversity of opinion prevails, we must bespeak the indulgence of our readers, not only for the imperfections, but for the errors into which we may fall. From the narrow limits, too, within which we are necessarily circumscribed, we are constrained to give rather the results than details of experiments; to avoid all discussion of disputable points; and to reject many practical illustrations and much historical narration. Neither have we room to enlarge on the general distinctions between plants and animals; on the importance of vegetables in the scale of being; their geographical distribution; the nature of their living power or vitality; their sensibility, perceptivity, and many other properties which have been ascribed to them. Our aim will be solely confined to give, as concisely and perspicuously as we are able, such a general view of the leading and more important functions of the more perfect vegetables as the present state of our knowledge will permit. To the article above mentioned we shall continually refer for such anatomical details as our physiological explanations may require: and, proceeding on the views of structure there delivered with regard to the Elementary Systems of plants, we shall follow nearly the order observed when treating of their individual members and organs, and commence our discussions with a description of the germination of seeds.

CHAP. I.

Of the General Functions of Vegetables.

Sect. I.

Of the Germination of Seeds.

In the article referred to we have detailed pretty fully the anatomy of seeds (§ 173), and described particularly their tunics and the nucleus contained within them. This nucleus consists of the organized parts, or embryo, and the inorganic matter destined to afford it nourishment. In size and figure the organized parts vary much in different seeds, and thereby constitute an embryo more or less developed or perfect. In its more complete forms, this embryo consists of the radicle, the stem, and the plume. The stem, however, is often not distinguishable. When present, it connects the radicle with the plume, and the place of its junction with the radicle is denominated the *neck* of the embryo. In the progress of evolution, the radicle descends to form the root, and the plume rises and constitutes the first bud of the new plant.

Beside the organized parts just mentioned, there are others called cotyledons, which derive their origin from the embryo. Many seeds have two cotyledons, and some more than two; others have only one, and some seeds have no cotyledon. When present, the cotyledons exhibit different forms; and between them and the embryo, a vascular communication is established, as may be seen in the dissection of a bean, represented in Plate XV. fig. 26, of Vol. I. Beside vessels, the cotyledons are partly made up of cells, within which the nutrient matter of the seed is contained. In some seeds, however, this matter is only partially contained in the cotyledons; in others, as that of wheat, it is wholly contained in a cellular tissue produced from the inner tunic. Lastly, the cotyledons of some seeds rise above the ground during germination, and perform the function of leaves: in others they continue beneath the soil. In all seeds their existence is temporary, for they perish after having yielded their nutrient matter to the embryo.

This matter, called *albumen* by Grew and Gærtner, is a secretion made by the vessels into the cells during the formation of the seed; and, though itself inorganic, is contained in an organized tissue. It is of various colour and consistence in different seeds. Its bulk, compared with that of the organized parts, is, in some seeds, very small; in others very large. Its appearance in the cells of the cotyledon of the bean, and of the inner tunic of wheat, is represented in Plate XV. figs. 24 and 25; and described in § 203, 204, 205, of our former article.

Such is a brief notice of the more important parts which construct the seed, and which it is necessary clearly to understand before we can properly appreciate the nature and effects of the actions that go on during its germination. In considering these actions, we have to inquire into the circumstances or conditions in which the seed requires to be placed —the agents which then act upon it—the change of quality and condition which these agents themselves suffer, and the effects which, in consequence, they produce in the seed—and, lastly, the physiological phenomena which thence arise, and terminate in those alterations of form and structure which constitute the evolution of the seed.

In general, seeds, when placed to grow, are buried more or less deeply in the earth, but this condition is not essential; for they readily shoot forth and display their forms, when confined in vessels of air. In whatever situation their germination is attempted, a certain temperature, and a certain portion of moisture, are necessary to its commencement; and the access of air is afterwards required to carry on the process. We have, therefore, to inquire into the operation of water, heat, and air, in commencing and carrying on the germination of the seed.

Water, in the first instance, penetrates the tunics of the seed apparently by simple attraction or imbi-

bition; and the force with which this attraction is exerted is well illustrated in the experiments of Boyle and Hales. They filled strong bottles with dry beans or pease, over which water was poured, and the bottles were then closely stopped. As the seeds imbibed the water, they readily burst the bottles asunder; or, if small iron cylinders, closed by a plug, were employed, the plug was gradually raised by the expanding seeds, though pressed by a weight of nearly 200 lbs. It is by the exertion of such a force, that certain seeds, as those of the peach and apricot, are able, says Du Hamel, to burst open their stony envelope. This expansion from the imbibition of water occurs not only in seeds which retain the faculty of germinating, but in those also which have lost it. We must, therefore, regard this first step in germination as similar to the attraction of water by inanimate bodies. Accordingly, if, after water has been thus imbibed, air be excluded, the radicle never increases beyond a certain size; and, if the seed be kept wholly immersed in water at a temperature of 60°, decomposition of its substance ensues.

To this imbibition of water, a temperature above that of freezing is necessarily required; and, within a certain range, the rate of expansion will be more or less influenced by that of temperature. Cold, however, does not destroy, but only suspends, the germinating faculty in seeds.

When, by the combined operation of heat and moisture, the seed is brought into a condition fit for germination, then the presence of air is required. Many experiments were made by Boyle and others, to prove the necessity of air to germination; and, since the composition of the atmosphere was made known, many more have been instituted to ascertain why the air is thus necessary, the nature of the changes it undergoes, the extent to which they proceed, and the manner in which they are accomplished. On all these points much information has been gained, and the results obtained are, in general, so precise, as to leave little doubt as to the nature and extent of the facts, whatever difference of opinion may exist as to the mode of their occurrence. We must refer those who desire full details on these subjects to the writings of Scheele, Cruickshank, Gough, De Saussure, Huber, and Senebier, &c. The results of their labours are given, more or less completely, in most of our chemical works, and are more fully detailed in Mr Ellis's *Inquiries into the Changes induced on the Air by the Vegetation of Plants, &c.* Parts I. and II.

From these results we learn, that atmospheric air is useful to germination, from containing oxygen gas: that, by the germinating process, the oxygen gas of the air is changed into an equal bulk of carbonic acid gas; and that the azotic portion of the air remains unchanged in composition, and in volume unaltered.

The nature and extent of the change induced on the air being thus ascertained, we have next to inquire into the mode in which it is brought about,—that is, how the carbonic acid is formed? Now, when the experiment is conducted in close vessels, no other substance, but the seed, is present that can afford carbon: and this fact, taken in connection with the circumstance that the seed actually contains carbon, and yields it, like other organized substances, to the atmosphere that surrounds it, authorizes the conclusion, that, while the air supplies the oxygen, the seed yields the carbon by which the carbonic acid of germination is formed.

Granting, however, that carbon is afforded by the seed, and combines with the oxygen of the air,—where, it may be asked, and in what manner, is this combination effected? A certain degree of moisture in the seed is necessary to enable it to yield its carbon; for, when perfectly dry, little or no reciprocal action goes on between the seed and the air. Neither does the living faculty of the seed seem necessary to this combination; for carbon is afforded by seeds when they are confined in vessels of azote or hydrogen gas, and even under actual decomposition. We may therefore regard the formation of carbonic acid, in the first stages of germination, as purely chemical; and as taking place either on the surface, or within the substance of the seed. Now, from the dense structure of the investing tunics, and the circumstance of the vessels of the seed being already filled with fluid, we see no way in which air can enter the seed, so as to act either on its organized or inorganic matter; and, consequently, we incline to the opinion, that the formation of carbonic acid takes place exterior to the tunics of the seed. Such, then, are the changes in composition which the air, employed in germination, suffers, and such appears to be the mode in which they are accomplished.

While these changes are produced in the air, others not less remarkable occur in the form and qualities of the seed itself; for not only are its organized parts gradually evolved, but its inorganic matter, besides being softened by the imbibed water, acquires, in many seeds, a sweetish taste. These facts, which had long been observed in the process of malting, were more distinctly ascertained by Cruickshank. He found that seeds of barley, when placed to grow in vessels, either of atmospheric air or of pure oxygen gas, acquired, in a few days, a sweetish taste, and were more or less completely converted into malt.

In what manner then, or by what agency, must we suppose this change in the inorganic matter of the seed to be accomplished? This matter, though denominated albumen, does not resemble the albumen of chemists. In vegetable physiology, the term comprehends the whole inorganic matter of the seed, although that matter may contain no real albumen, but consist of several distinct substances, or "proximate principles," as they have been called. The principal ingredients of seeds, which afford nutrient matter to the embryo, are mucilage, starch, and sugar. For a full account of the chemical properties of these substances, we must refer to the writings of chemists: our limits permit only a very slight notice of them.

Mucilage—the soft and liquid state of gum—is inodorous and insipid; soluble in hot or cold water, but insoluble in alcohol. *Starch (fecula)* is obtained from the flour *(farina)* of the more nutritive seeds. It is also insipid and inodorous: insoluble in alcohol, and even in water, unless raised to the

temperature of 160°. If heated to 180°, the solution then jellies, and, by evaporation, may be reduced to a substance closely resembling gum. *Sugar* exists abundantly in the juice and fruits of plants; but in seeds, it is formed chiefly during their germination. It is soluble both in hot and cold water, and also in alcohol. Other ingredients, as *gluten*, albumen, and oil, are found in particular seeds.

Of the "proximate principles" which contribute to vegetable nutrition, chemists have attempted to ascertain not only the elements, but the proportions in which they enter into the several compounds. All agree in making these elements to consist chiefly of carbon, hydrogen, and oxygen, and a few find also a minute quantity of azote; but the proportions assigned by different analysts for the same substance differ scarcely less than those allotted for the composition of the different substances. In the tabular view below, we have given the results obtained by different chemists, in analyses of mucilage, starch, and sugar—the three substances more immediately connected with our present purpose; and also of woody fibre, which they contribute to form.

Vegetable Physiology.

Substance.	Carbon.	Hydrogen.	Oxygen.	Azote.	Analyst.
Mucilage, or Gum,...	42·23	6·93	50·84		Gay Lussac and Thenard.
	41·906	6·788	51·306		Berzelius.
	45·84	5·46	48·26	0.44	De Saussure.
	35·13	6·08	55·79	3·?	Ure.
Starch,..................	43·55	6·77	49·68		Gay Lussac and Thenard.
	43·481	7·064	49·455		Berzelius.
	45·39	5·90	48·31	0·40	De Saussure.
	38·55	6·13	55·32		Ure.
Sugar,..................	42·47	6·90	50·63		Gay Lussac.
	42·704	6·891	50·405		Berzelius.
	37·29	6·84	55·87		De Saussure.
	43·38	6·29	50·33		Ure.
Oak-wood................	52·53	5·69	41·78		Gay Lussac and Thenard.
Beech-wood..............	51·45	5·82	42·73		Do. do.
Flax	42·81	5·05	51·07		Ure.

From this view, it is clear that no conclusion, with regard to the sensible properties of these substances, can, in the present state of chemical analysis, be inferred from their elementary composition.

Deriving, from the ultimate analysis of these substances, but little aid in explaining the chemical changes they undergo, we must recur to other modes of accounting for those alterations in their sensible qualities which germinating seeds exhibit. In the germination then of many seeds, the hard and insipid albumen is gradually reduced to a milky form, and acquires a sweetish taste; while the organized parts become, at the same time, softened and expanded, and prepared to take on those actions, and exhibit those specific forms, which constitute the developement of the embryo. Now, the only agents which act simultaneously on the several parts of the seed, when this developement occurs, are water, heat, and air; and, as far as we have been able to trace their operation, the changes produced in the seed must therefore arise, more or less, from the action of heat and moisture; or from the loss of carbon; or from some specific agency exerted directly by the oxygen gas of the air; or arising indirectly out of its conversion into carbonic gas; or from the combined operation of these several agents. Let us then examine their operation, both separately and conjointly, and try to discover the share which each exerts in the production of these changes.

It has been shown that neither heat alone, nor moisture alone, nor both united, are able to produce the developement of the seed; but that these agents contribute to bring it into a proper state for being acted on by the air. In what manner, then, does the air act on the germinating seed? No direct effect can be ascribed to its azotic portion: for that gas neither suffers nor produces change in germination, and the process goes on perfectly well either in pure oxygen gas, or in gaseous mixtures which contain no portion of azote.

But oxygen gas is essential to germination, and by that process is uniformly converted into carbonic acid gas. This disappearance of oxygen has led to the belief, that while a part of it was converted into carbonic gas, another portion actually *combined* with the seed, and contributed to its developement. But it is well ascertained, that oxygen gas, by its conversion into carbonic acid, suffers no change of volume; and as the bulk of that acid gas, produced in germination, equals exactly that of the oxygen which has disappeared, it follows, that no portion of the oxygen, lost by the air, combines with the seed, but really exists exterior to it in the form of carbonic acid gas. The only other source from which the seed, in the experiments referred to, could derive oxygen, is from the decomposition of water; but germinating seeds, says M. De Saussure, emit neither hydrogen nor oxygen, but only convert the oxygen gas of the air into an equal bulk of carbonic acid gas. It seems, therefore, to be quite certain that the changes produced in the germinating seed cannot arise from the combination of oxygen.

Neither, in conformity to the opinion held by some, that the mucilage of the seed becomes sugar by losing a part of its carbon, can we ascribe the change of quality in the seed to the loss of that substance: for the portion of carbon given off by the germinating seed is exceedingly small, and we have no evidence that it is afforded by its mucilaginous matter. Were it even granted that the albumen of the seed yielded the carbon, this would not prove that it is thereby converted into sugar: for we have no evidence that the sensible qualities of bodies depend so immediately on their elementary composition; and a reference to the tabular view before given, will show that, while one chemist makes the carbon in mucilage to be less than in sugar, another makes it to be more, and a third makes it, in both substances, to be almost precisely the same. We shall presently see, too, that the chemical change, by which mucilage is converted into sugar, takes place in circumstances where there is no reason to ascribe it to the loss of carbon.

Since, then, neither the operation of heat and moisture, nor the loss of carbon, will account for the changes that occur in the germinating seed, and since all the oxygen lost by the air exists in the carbonic gas that is formed, we must look for an explanation of the *uses* of the air, not to its ponderable elements, but to the action of that caloric which is extricated whensoever its oxygenous portion is converted into carbonic acid gas. We shall not at present speculate on the state or condition in which this caloric, at the moment of its extrication, exists, nor on the mode of its action upon the seed; but we may observe, that ignorance of the mode in which an agent may act is no valid argument against the fact of its operation. If the agent employed be actually present, and every other assumed agent be excluded, we are entitled to decide in favour of its agency, although we may not know the mode of its operation. Those who formerly believed that oxygen produced these changes, or who may still believe so, never explained the mode of its operation. Their belief rested on the supposition that a part of the oxygen that disappeared really combined with the seed; but as no such loss of oxygen occurs, no such combination can be allowed to follow.

Beside the caloric derived from the air, a portion of heat may be afforded by the imbibed water; for Mr Leslie has shown that very small portions of water, when imbibed by dry vegetable substance, give out heat; and M. De Saussure has rendered it probable that a portion of water loses its fluidity in vegetation, and that its elements combine with the vegetable substance,—an opinion which would agree well with the analysis of Gay Lussac and Thenard, should future experience confirm their views, that oxygen and hydrogen, in the proportion necessary to form water, constitute a large portion of vegetable matter.

That the combined action of heat and moisture will produce on the *fecula* of seeds changes analogous to those which occur in germination, has been long known. Dr Irvine long since remarked, that the farinaceous matter of seeds could thus be rendered sweet. Hence distillers, says he, often mix not only grain imperfectly malted, but raw meal, with their malt; and the whole being then mixed with water, and submitted to distillation, becomes sweet, and forms wine and spirits. MM. Fourcroy and Vauquelin obtained sugar and alcohol from bruised unmalted barley, by the combined use of water and heat; and Dr Thomson has remarked, that the wort made from raw grain is nearly as sweet as from that which has been malted. In the experiments of M. Kirchoff and others, starch was converted into sugar by 36 hours boiling in four times its weight of water; and, from some later trials, it would seem that saw-dust and other vegetable matters, as linen rags, may, by a similar process, be made to experience a like conversion. From these experiments we learn, that the conversion of the *fecula* of seeds into sugar is an operation purely chemical, effected by the combined and continued action of heat and water; and since, in germination, the albumen of the seed is made to undergo a similar chemical change, under the varied operation of the same agents, may we not presume that it is accomplished in a manner somewhat similar?

When, by germination, the albumen of the seed has been thus changed from a solid and tasteless, to a fluid and sweetish substance, it is brought into a condition fit for the nutrition of the embryo. For this purpose, it is taken up, or absorbed from the cells in which it had been deposited, and conveyed, in the course of the mammary vessels, to the neck of the embryo, where a part of it is carried downward to feed the radicle, and another part upward to nourish the plume. We have elsewhere (§ 79) given reasons for believing that the same vessels, which, during the *formation* of the seed, secreted the nutrient matter into the cells, are employed, at the period of its *evolution*, in absorbing it from them, and consequently possess the power, by thus acting at different times, and under different circumstances, of executing opposite functions.

Connected with the structure that determines the course which the nutrient matter takes on reaching the neck of the embryo, appears to be that tendency in the plume and radicle to pursue opposite directions, in whatever position or circumstances the seed be placed to grow. These tendencies have been ascribed to the action of light on the plume, and of earth on the radicle: but the radicle equally descends, although no earth be present, and the plume rises, although light be excluded. Others have attributed the descent of the radicle to the greater weight of its sap, and the ascent of the plume to the lighter condition of that fluid: but there is no evidence that, in these parts respectively, any such difference of sap exists. More lately, it has been supposed that gravitation acted in causing the descent of the radicle; and attempts have been made to counteract this force, by keeping seeds, during their evolution, in continued motion on vertical or horizontal wheels: but the results obtained seem only to prove, that, in such circumstances, the radicle and plume pursue, as usual, opposite directions, without affording any reason, why, in natural growth, the one always rises and the other descends. It is worthy of remark, that this tendency to descend exists only in the

primary radicle or tap-root: for the lateral shoots it puts forth extend themselves, says Du Hamel, nearly horizontally. In like manner, the rootlets that spring from the extremity of a cutting descend perpendicularly, while those that issue from its sides proceed horizontally. We may observe, too, a corresponding peculiarity in the plume and its productions. It is very singular, continues Du Hamel, that a tree which springs from a seed raises its stem very straight: it is the same with a cutting taken from a straight stem: but a cutting taken from a lateral branch, or the bent shoot of a tree, bends much in its growth, especially if its wood be of a hard nature. Some trees, we know, have branches so feeble as to be unable to support themselves, and are therefore always pendent: and Du Hamel once saw a branch of a walnut tree, which, contrary to all the other branches of the same tree, descended straight to the earth, and all its leaves followed the same direction. These facts seem to show, that the directions pursued by these several parts in their ordinary growth, depend rather on conditions of internal structure, than on the operation of external agents.

Both the radicle and plume, as they receive nutriment, increase in all their dimensions; that is, both in length and breadth. The elongation of the radicle, according to Du Hamel, is produced only by the addition of new matter to its extremity, an opinion which the observations of Mr Knight confirm. In the more succulent plume, Du Hamel has shown, by satisfactory experiments, that elongation is produced by an extension of parts already formed, as well as by the addition of new particles; but this extension is not observed when the new parts have acquired a certain degree of hardness. In their diametral growth, it is probable that both the radicle and plume experience, in their tender state, some degree of expansion from the motion of their contained fluids, as well as from the addition of new matter to their exterior surface.

In this brief account of germination, we have supposed the process to be carried on in closed glass vessels, in which the progress of evolution can be observed, the agents concerned in carrying it on made known, and their action, to a certain extent, be appreciated. In such vessels the developement of the seed can be continued until all the nutrient matter is exhausted, and the organized parts assume their peculiar forms, and execute their appropriate functions. If, indeed, water and air be duly supplied, the seeds of various herbs will grow and produce flowers and fruits without coming in contact with earth, as M. Bonnet ascertained; and in other experiments of Du Hamel, the seeds of different trees, which had been made to germinate on wet sponges, and their roots afterwards set in bottles so as to be in contact with water, continued to vegetate for several years, and produced annually new leaves, bark, and wood, by the aid of water alone; so that, "without attempting to explain how the parts of this fluid become solid, it is certain," says this excellent writer, "that water the most pure is able to furnish the nourishment necessary to plants." For a description of the daily appearances exhibited in the evolution of several kinds of seeds, we must refer to § 209, &c. of our former article, and to Plates XV. and XVI., for accurate representations of them.

In ordinary germination, however, by the time the nutrient matter of the seed is exhausted, the radicle has sent forth rootlets through the soil, which at once serve to fix the plant in its place, and to draw from the earth fresh materials to sustain its growth. These materials, as will afterwards be shown, undergo certain changes in the young leaves, which have now sprung forth from the plume, and in part execute the function of cotyledons. The cotyledons, if they have risen above the surface, now fade and fall; if they have remained beneath it, they decay and perish. In addition to water, heat, and air, the only agents required to carry on the germination of the seed, light now becomes necessary to give perfection to the plant; and its operation in bestowing colour and other peculiar properties on plants will be more particularly noticed hereafter. In this account of germination, we have given attention chiefly to the physical phenomena it exhibits, reserving what we have to say of the seed, as a living body, to another occasion.

Sect. II.

Of the Vegetation of Plants.

Art. I.—*Of Soils and of the Food of Plants.*

The plant, like the seed from which it sprang, is constructed of two elementary systems, denominated vessels and cells. For a detailed account of these, and of the opinions held concerning them, we must refer to our former article. By these systems, variously blended and combined, the several Textures, denominated Cuticle, Bark, Wood, and Pith, are composed. The structure of these textures, as they occur in different varieties of herbs and trees, has likewise been described in § 104, &c. of that article.

Though the vessels of plants differ in form and structure, yet, with regard to use, they appear to be but of two kinds:—those, namely, which receive and convey the common sap or lymph, and are named, therefore, Sap or Lymphatic Vessels,—and those which contain and convey the juices proper to each species of plant, and are therefore denominated "Proper Vessels." In trees, the sap-vessels are found chiefly in the wood, and the "proper vessels" in the bark; but in many herbs and in palms, both kinds of vessels are associated together through the entire stem. Whether they occupy distinct places in the vegetable, or are associated together, their functions are respectively the same—the sap-vessels being employed always in raising the sap upward, and the proper vessels in conducting its descent.

In all parts of plants, the vessels are in contact with cells, which serve sometimes the purpose of a connecting medium; sometimes to fill up vacuities or augment the bulk of parts; and sometimes as receptacles for various secretions. Between the vessels and cells a vascular communication exists (§ 132); so that matter deposited at one time in the cells of the plant may, at another, be taken up and again mixed with the fluids, as occurs in the germinating seed: and these functions of internal secretion and absorption seem to be performed in plants, as well as in seeds, by the alternate exercise of the same vessels,

acting at different times and under different circumstances.

Although, as we have seen, plants not only grow, but produce flowers and fruits without the aid of soil; yet, in ordinary circumstances, they draw the materials of their food from the earth. In an inquiry, therefore, into the nutrition and growth of plants, we have to consider the nature and properties of soils, which afford them habitation and nutriment—the absorption of this nutriment and its conveyance through the vessels—the changes of quality it experiences in its course, so as to fit it for nutrition—the agents required to effect these changes, and the mode in which they act—and lastly, the manner in which this nutrient matter, after having undergone its destined changes, is applied to nourish and augment the plant.

The soils in which plants grow are composed of organized and inorganic matters in various proportions. Of inorganic substances, the earths which prevail most are silica, alumina, and lime. With these earths, magnesia and certain metallic oxides, particularly that of iron, are often met with. To these we may add alkaline matter, and animal and vegetable substances in different stages of decomposition and mixture. According to the proportions in which these mineral and organized remains are present and blended together, the soil will vary greatly in texture, in its property of retaining heat and moisture, and in its degree of fertility. To say, however, what mixture of substances constitutes the most perfect soil would be very difficult: for not only does climate greatly modify the natural condition of soils, but plants themselves exhibit the greatest diversity of choice or liking in this respect. Hence it is, that the soil and climate best suited to one plant, are ill adapted or unsuited to another; and that every part of the earth's surface, in which heat and moisture sufficient to sustain vegetation are present, is more or less clothed with its appropriate species of plants.

In considering physiologically the *uses* which the different ingredients of soils serve in vegetation, we must bear in mind that certain chemical elements seem essential to the constitution of vegetable matter; while others, though present and highly useful, are not so indispensably necessary. Thus we have seen, that the vegetable substances, gum, starch, and sugar, are composed essentially of oxygen, hydrogen, and carbon; and that woody fibre, when freed from all adventitious matter, is found to be composed of the same elements, united nearly in the same proportions. Now, considering woody fibre as the basis of the vegetable organs, and as formed, in germination, directly from the *fecula* of the seed, and probably the water in which it is dissolved, we may presume, that the elements which thus compose fecula, water and woody fibre, are the true constituents of vegetable matter.

In certain kinds of vegetable matter, which approximate to animal substance, azote, however, is a necessary ingredient. In other kinds, the vegetable substance partakes largely of the earthy materials of the soil. Hence lime and silica are abundant in certain plants; but as such substances can enter plants only in a state of solution, the earths met with in vegetables may not, says De Saussure, depend so much on those which constitute the basis of the soil, as on those held in solution by the water it contains. Some have even supposed that the earths may be formed or generated in plants by the vegetative process; but the facts alleged in support of this opinion are not sufficiently precise. While, therefore, it is admitted, that earths are carried into plants, and, in certain tribes, enter largely into the composition of some of their textures, we have no evidence that they contribute directly to nutrition, or form an essential element in the composition of vegetable matter. Their use in affording station or habitation to vegetables is sufficiently obvious; and the temperature and moisture of the soil will also depend much on their kinds, proportions, and intermixture.

Together with the earths, chemical analysis shows, that sulphur, phosphorus, some metallic oxides, and particularly alkaline matter, exist in plants. Certain saline substances seem, indeed, necessary to vegetation. Marine plants languish in a soil destitute of common salt: and it is well known, that potash forms a large portion of the incombustible matter of land vegetables, and is especially abundant in the leaves. De Saussure found phosphate of lime in every plant he analysed. Certain plants throve well only in soils containing nitrates of lime or potash; and sulphate of lime or gypsum accelerated much the growth of lucerne and trefoil. These saline ingredients are highly useful, and the alkalis, in particular, seem necessary to the due perfection of the vegetative process; but, as the elements of these substances do not form a necessary constituent of the vegetable fibre, they cannot be considered as an essential part of the food of plants. Perhaps they may be regarded as condiments which aid in the process of assimilation; and, as will appear, they are otherwise highly useful in the vegetable economy.

With regard to the organized remains, which form so large a portion of the most fertile soils, they are not only soluble in water, like the other ingredients, but are composed of the same elements as vegetable substance. M. De Saussure found pure vegetable mould to yield, by distillation, products similar to those of the undecayed wood from which it had been formed, differing chiefly from it by containing a larger proportion of charcoal and some azote. Water dissolved a portion of this mould, and when deprived of this soluble portion, the residue, though unaltered in appearance, did not support the growth of plants so well as before. The part thus dissolved by water exhibited the properties of *extractive*,—a principle found in the sap, and especially in the bark of plants. Hence it appears, that decayed vegetable matter, and the same may be said of animal remains, is not only conveyed into plants, but, being formed of the same elements as the living plant, may be conceived to furnish materials necessary to its growth.

But in all soils adapted to vegetation, water is a necessary ingredient, whether it be regarded merely as a vehicle for the conveyance of other substances, or as forming itself a portion of the food of plants. To the experiments of Van Helmont, Boyle, Bonnet, Du Hamel, and Braconnot, tending to prove that water alone affords nutriment to plants, it has

been objected, that the water they employed, though apparently pure, held in solution both earthy and saline matters; but, unless we suppose these matters convertible into oxygen, hydrogen, and carbon—the only essential elements of vegetables—the presence of these earths and salts in the water could not supply the elements required for the production of vegetable matter. If, on the other hand, with Du Hamel and De Saussure, we suppose water, though not decomposed, to lose its fluidity, and become fixed in vegetables, then we have at once two of the elements of woody fibre, combined, too, in that proportion which the experiments of Gay Lussac and Thenard exhibit them as holding in the composition of vegetable substance.

Of the source of the other element, carbon, it is not less difficult to speak. It is an ingredient of vegetable mould, and of the carbonic acid carried into plants with the sap, either in a free state, or in combination with alkaline matter; so that, by these means, it is pretty largely supplied to plants. On the other hand, M. Hassenfratz endeavoured to show that plants which vegetated in the open air by the aid of pure water, yielded, on analysis, less carbon than the seeds or bulbs from which they had sprung. M. De Saussure obtained similar results when he analysed plants that had grown in pure water, and in a place weakly illuminated; but when they grew under the direct influence of light, then the proportion of carbon in the plant nearly doubled that in the seed. This carbon M. De Saussure supposes to be derived from that decomposition of carbonic acid which is carried on by the leaves of plants growing in sunshine. Admitting this to be the fact, we may perhaps regard the carbon thus deposited in the leaf as contributing rather to the formation of the inflammable products of the plant, than as undergoing *assimilation*, and being applied to the production of new vegetable substance. And hence, as will afterwards be shown, plants which grow in darkness not only contain less carbon than those which grow in light, but are at the same time destitute of those imflammable ingredients which plants growing in light possess.

Beside the earth and water, the air also has been supposed to furnish food to plants. That plants obtain moisture from the air will not be denied; and in as far as water is concerned in vegetable nutrition, the moisture thus obtained may contribute to vegetable growth. But they have also been supposed to derive carbon from the atmosphere, by decomposing its carbonic acid. Since, however, the atmosphere contains less than $\frac{1}{1000}$th part of carbonic acid gas, the portion of that gas decomposed by plants in the open air must, even in sunshine, be necessarily very small, and the quantity of carbon thus obtained is probably much exceeded by that continually given off by plants to unite with the oxygen gas of the atmosphere, through every period of active vegetation. M. De Crell, indeed, deeming the carbon that could be afforded by the atmosphere insufficient to account for the addition of that substance which plants, during their growth, receive, was led to suppose they possessed the power of forming carbon by the aid of water, air, and light; and M. Braconnot has maintained that vegetables find in pure water every thing necessary for them to assimilate; that mould and manures yield no nutriment; and that earths, alkalis, metals, sulphur, phosphorus, and charcoal, are developed from water, by the organic powers of plants assisted by solar light.

"But the experiments," says Sir Humphry Davy, "in which it is said that alkalies, metallic oxides, and earths, may be formed from air and water alone in processes of vegetation, have been always made in an inconclusive manner: for distilled water may contain both saline and metallic impregnations; and the free atmosphere almost constantly holds in mechanical suspension solid substances of various kinds. The conclusions of M. Braconnot," he adds, "are rendered of little avail in consequence of these circumstances. In the only case of vegetation in which the free atmosphere, in his experiments, was excluded, the seeds grew in white sand, which is stated to have been purified by washing in muriatic acid: but such a process was insufficient to deprive it of substances which might afford carbon, or various inflammable matters.

"In the common processes of nature," continues this illustrious chemist, "all the products of living beings may be easily conceived to be elicited from known combinations of matter. The compounds of iron, of the alkalies and earths with mineral acids, generally abound in soils. From the decomposition of basaltic, porphyritic, and granitic rocks, there is a constant supply of earthy, alkaline, and ferruginous materials to the surface of the earth. In the sap of all plants that have been examined, certain neutro-saline compounds, containing potash, soda, or iron, have been found. From plants they may be supplied to animals; and the chemical tendency of organization seems to be rather to combine substances into more complicated and diversified arrangements, than to reduce them into simple elements." (*Phil. Trans.* 1808.) To these views of the economy of living beings, we yield our cordial assent, and hold them to be not less consistent with the most advanced state of chemical science, than with the justest conceptions we can form of the varying structure and powers of organic beings.

ART. II.—*Of the Course of the Sap, and the Causes of its Motion.*

In the warmer regions of the earth, the sap flows, in certain plants, through the whole year; but in more temperate climes the functions of vegetables are suspended during the winter season. Early in spring, however, it begins to rise in trees, and continues daily to ascend till it reaches the extremities of the branches. This sap is absorbed from the soil by the extremities of the capillary rootlets, and conveyed upwards through the vessels of the root to the trunk. In its ascent it rises only through the wood; for, at this early period, no sap is found in the bark, nor between it and the wood, nor in the pith. (§ 12.) This rise of the sap occurs *before* the buds have shot forth into leaves; and as no outlet for its escape by transpiration then exists, it rises or falls in the vessels in which it is contained according to the temperature of the atmosphere. If at this period of its flow,

its course, in certain trees, be intercepted, by piercing the vessels of the trunk in any part, it issues forth, and may be collected for examination. In this way the vine, the birch, and sugar-maple, yield sap, or *bleed,* as it is called, very abundantly. They bleed also from the extremity of a cut branch, if the experiment be made sufficiently late in the season, but still *before* the appearance of the leaves.

Early in February, before the sap began to flow, Dr Walker made several incisions, at different heights, in a birch tree, in order to observe its motion. No sap was visible at the lowest incision in the trunk till the temperature of the atmosphere rose to 46° in the shade: after which, as the temperature augmented, the sap continued daily to rise. When the highest incision in the trunk, at the height of thirty feet, bled, the thermometer was at 52°; and when the tree bled, not only from the incisions in its trunk, but from every cut extremity of its branches, it was at 56°. During the whole experiment, when the temperature was nearly the same, the sap continued nearly stationary,—rising again, as the temperature rose, just like the fluid in a thermometer. To the cut extremity of a vine branch, Dr Hales, in the bleeding season, cemented long glass tubes, so that he could readily observe the movements of the sap. Into these tubes it would rise many feet through the morning after the sun was up; but while in this rising state, if there was a cold wind, or the sun was clouded, the sap would immediately subside, at the rate of an inch in a minute, for several inches: but as soon as the sunbeams broke out again, the sap would immediately return to its rising state, just as any liquor in a thermometer rises and falls, says Dr Hales, with the alternations of heat and cold.

To ascertain the force and velocity of the sap's motion at this season, Dr Hales made many experiments. He found it to rise in glass tubes at the rate, sometimes, of an inch in three minutes, and to attain the height of more than 20 feet. In other experiments, it exerted a force sufficient to sustain a column of mercury at the height of 38 inches—a force, says he, five times greater than that of the blood in the crural artery of a horse. In the chief bleeding season, the sap continued to rise by night and by day, but more in the day, and most of all in the greatest heat of the day: and when the sun shone hot upon the vine, a continued series of air-bubbles rose through the sap, so as to make a large froth on its top.

Such are the phenomena exhibited by the rising sap *before* the appearance of the leaves: when they have shot forth, a great change is observed in its movements. It still, however, continues to rise through the trunk; but if the wood be now pierced, none of it flows out, as it did in the bleeding season. In the excellent experiment of Dr Walker, already referred to, the birch tree continued to bleed from the 5th of March to the 24th of April, on which day it bled from every incision in its trunk, and every cut extremity of its branches. On the 30th of April, vernation or budding began, and the young leaves shot forth. As they advanced, the bleeding gradually lessened, till at length, on the 10th of May, when the leaves were fully expanded, all the incisions, says Dr Walker, which had yielded sap so freely were every where dry; and this, not from evaporation by the leaves, but from a general diffusion of the sap from the wood through the bark at that season. In conformity with these observations, Dr Hales remarks, that, after the appearance of the leaves, the bark, which was before dry and adhered to the wood, becomes lubricated with sap, and separates easily. Even after the bark has thus been brought to separate from the wood in a young tree full of sap, if all the leaves, says Du Hamel, be stripped off, the bark, in two days, will again adhere to the wood, and continue to do so through the winter. These facts distinctly prove that, after the leaves have sprung forth, the sap of plants is no longer confined to the wood, but finds its way into the bark; and we have next to trace its route into that texture.

MM. De la Baisse and Bonnet traced the sap of plants from the extremities of the roots into the leaves and flowers; and when the plants were set in coloured liquors, the fluid was seen to pass from the vessels of the leaf into its cellular tissue, and the bark of the petiole afterwards to become tinged. The communication thus established between the wood and the bark, M. Bonnet considered to occur in the extreme ramifications of the leaf, where, as he supposed, the ligneous and cortical vessels mutually anastomose. In a plant of Euphorbia, set in a coloured liquor, Dr Darwin observed the fluid to run along the inner ring of vessels in the petiole to the upper surface of the leaf; while on its under side, a white fluid was seen to return from the extremities of the same leaf, and to descend, by the exterior ring of vessels in the petiole, into the bark. In similar experiments on the apple branch, Mr Knight followed the returning fluid through the bark, by the vessels of which it seemed to be conveyed to the roots. These facts show that the sap, which is observed in the bark, after the leaves have sprung forth, gets into that texture by passing through those organs.

The leaves, which thus form the organs of communication between the wood and the bark, not only vary the course of the sap, but greatly influence its motion. Before their appearance, no natural outlet for its escape existed, and it therefore rose, continued stationary, or fell in the same vessels, chiefly according to variations of temperature. But when the leaves are developed, a large portion of the sap, in its passage through them, is thrown off by transpiration, and the remainder is conveyed into the bark; so that, by these means, the vessels of the tree are emptied, and put into a condition to attract fresh portions of fluid. Hales found, accordingly, that amputated branches of trees, which were furnished with leaves, and set in glass tubes of water, attracted from fifteen to thirty ounces of water in the course of the day; while similar branches, from which the leaves had been stripped off, imbibed, in the same time and circumstances, not more than one ounce. In like manner, a growing vine, which was perspiring abundantly by its leaves, ceased at once to yield sap from its stem, when cut over *below* the leaves. He found also that amputated branches, when plunged in water, imbibed from the small end to the great

end as well as in the opposite direction; that they imbibed also when deprived of their bark, but not when stripped of their leaves; and that they would imbibe water from their small cut extremity, while still attached to the trunk. Hence it appears, that, after the period of vernation, the flow of the sap is promoted chiefly by perspiration from the leaves; and, therefore, if the leaves be removed, or their perspiration counteracted by a cold and humid atmosphere, then, as Hales found by experiment, the attraction of fluid by the sap-vessels is proportionally diminished.

To find the force and velocity with which the sap moved in this more advanced stage of vegetation, Dr Hales cemented branches of trees, furnished with leaves, in glass tubes filled with water, and then set the lower end of the tube in a vessel of mercury. As the water was attracted by the branch, the mercury rose into the tube, in one instance to the height of twelve inches in seven minutes. When the mercury had reached its greatest height, it would hold to that height for several hours in a warm sunshine, which favoured perspiration from the leaves; but as the sun declined or set, perspiration decreased, and the mercury ceased to rise. So great at this season is the attractive force of the leaves, that if a notch be cut in the trunk of a tree through which the sap is rapidly flowing, yet will the notch remain dry; "because," says Hales, "the attraction of the perspiring leaves is much greater than the force of trusion from the column of water." By other experiments he ascertained, that, when once the motions of the sap have been brought under the dominion of the leaves, the sap-vessels of the root no longer possess the same power of forcing the sap upward, as they did in the *bleeding* season; but so long as the leaves throw off the sap, the roots more or less abundantly attract fresh supplies of it from the earth.

In these various motions of the sap, both before and after the bleeding season, Dr Hales ascertained that the tree underwent no variation in its dimensions; yet, whenever it rained, the stem very sensibly dilated, and when the weather again became dry, it subsided as much. "This shows," he adds, "that the sap, in all stages of vegetation, is confined in its proper vessels, and does not confusedly pervade every interstice of the stem, as the rain does, and thereby dilate it." Du Hamel also noticed this alternate augmentation and diminution in the size of trees, under the different states of a humid and dry atmosphere.

Beside this perpendicular ascent, there is also, in certain circumstances, a *lateral* motion of the sap. Dr Hales cut four large gaps in the branches of different trees, at several inches distance from each other. The cuts were carried down to the pith, and opposed, in position, to the four points of the compass. If the cut branches were then amputated and immersed in water, they imbibed that fluid by their extremities; but not so abundantly as before, and continued to give it off freely by their leaves; if they remained attached to the tree, after such gaps were made in them, both the leaves and fruit of the branch flourished as well as those on other branches of the same tree—proving, says Hales, a very free *lateral* passage of the sap, where the direct passage had been several times intercepted. In these gaps, no moisture could, at any time, be either seen or felt, notwithstanding much fluid was passing by, because the stem, above the gaps, was in a strongly attracting state to supply the great perspiration of the leaves. Mr Knight made similar incisions on the opposite sides of apple branches during the winter season; yet, through these branches, the sap flowed in spring, and pushed forth the buds as usual.

From the facts stated above, it appears, that, *before* the period of vernation, temperature is the chief agent in promoting the flow of the sap; and that, *after* that period, its progress is aided principally by perspiration from the leaves. There must, however, exist in the plant itself some condition or structure which favours the operation of these agents. At different periods, different causes have been assigned for the ascent of the sap. It has been supposed to exist in the state of vapour, and its ascent been ascribed to its levity; others have attributed its rise to some imagined action of the spiral vessels; others to fermentation, or to the mechanism of valves; and others to a power of contraction and dilatation in the vessels, or to capillary attraction. Of these alleged causes, the two last alone deserve particular notice. That a contractile power, derived from a vital source, is not necessary to the motion of the sap in plants, seems certain from the fact of the ready transmission of fluids through dead vegetables. Even the dissevered particles of vegetables, as the ashes of wood, were found by Hales capable of attracting water with a force nearly equal to living organized structures. From these and other facts, he considered the rise of the sap to be produced by capillary attraction, aided by temperature, and especially by perspiration from the leaves. "For, without perspiration, the sap," says he, "must necessarily stagnate, notwithstanding the vessels are so curiously adapted, by their exceeding fineness, to raise the sap to great heights in a reciprocal proportion to their very minute diameters."

The force of capillary attraction, when thus aided by evaporation, is strikingly illustrated by an experiment of Professor Leslie: he found that the attractive force, exerted by the very fine pores of a thin hollow ball of earthenware, from which water was continually evaporating, was more than sufficient to support a load of mercury, in a tube attached to the ball, equal to that of 400 inches of water, or a column of 34 feet of that fluid. He estimates the diameters of the pores in the ball at the 10,000dth part of an inch, and supposes the pores in the leaves of plants to possess nearly the same dimensions. "As fast, therefore," says he, "as their humidity is exhaled into the atmosphere, it is constantly supplied by the ascent of sap from the roots."—(*Elem. Nat. Phil.* I. p. 328, 329.)

Still, however, though capillary attraction, when aided by perspiration from the leaves, may exert great influence over the motion of the sap, it is yet probable that some power or property, inherent in the vessel as a living organ, assists its action. The direct effect of heat in promoting the flow of the sap in the bleeding season, and of cold in retarding it,

seems to be more connected with some living property in the vessels, than with their powers as simple capillary tubes. If this heat be supposed to dilate the vessels, it ought to check capillary action, and cold, by diminishing their diameters, ought to increase it: but the results afforded are exactly the reverse of these. "If a capillary tube," says Dr Thomson, "be taken of such a bore that a fluid will rise in it six inches; and if, after the fluid has risen to its greatest height, the tube be broken short three inches from the bottom, none of the liquid in the under half flows over."—"But if we cut a plant, the *Euphorbia peplis*, for instance, in two places, so as to separate a portion of the stem from the rest, the milky juice of that plant flows out at both ends so completely, that if afterwards we cut the portion of the stem in the middle, no juice whatever appears. Now, the diameter of these vessels is so small, that, if it were to continue unaltered, the capillary attraction would be more than sufficient to retain their contents, and consequently not a drop would flow out. Since, however, the whole liquid escapes, it must be driven out forcibly, and consequently the vessels must contract."—(*System of Chemistry*, Vol. IV.) From similar experiments, Du Hamel inferred that the "proper juice" is forced out by a contraction of the vessels that contain it.

ART. III.—*Of the Qualities of the Sap, and the Changes it undergoes in the Leaves from the Agency of the Air.*

Having said so much of the *motion* of the sap, and of the powers by which it is accomplished, let us next direct our attention to its *qualities*. If collected during the bleeding season, it is almost without taste, but sometimes a little sweet. It ordinarily yields, by evaporation, only a little mucilage, but that of the maple of Canada is said, by Du Hamel, to afford nearly 5 *per cent.* of sugar. The sap of the elm (*Ulmus campestris*) was examined by M. Vauquelin at successive periods of vegetation. In his first analysis he found 1039 parts of it to consist of

1027·904 water and volatile matter;
9·240 acetate of potass;
1.060 vegetable matter;
0·796 carbonate of lime.

At a later period, the vegetable matter was in greater quantity, and the saline ingredients had diminished; and, at a period still later, these changes were still more evident. Other saps were analysed, and found to possess similar ingredients; and some others in addition. The sap of the beech contained gallic acid and tannin; and that of the birch, sugar, and acetites of alum and lime. The sap of the vine, examined by Dr Prout, resembled river water in appearance and specific gravity, but was sweetish to the taste. It yielded, by evaporation, a minute portion of *residuum*, consisting of a peculiar vegetable matter and carbonate of lime.

The increase of vegetable matter observed in the sap as the season advances, suggests the idea that it becomes mixed with matter previously deposited in the tree. This idea occurred to Malpighi, who considered the sap, as it rose through the vessels, to be partly deposited in the cells, where it underwent changes which fitted it for supplying the first nutriment to the young buds and tender leaves. A similar opinion was held by Darwin, who also regarded the sweet juices found in certain roots, and in the knots and stems of some of the grasses, to serve the same purpose. From finding the specific gravity of the sap to increase as it rose higher in the tree, and the alburnum of a tree, felled in winter, to be heavier than in other seasons, Mr Knight also supposed a deposition of nutrient matter to be made in the alburnum, through the latter part of summer and autumn; so as to be ready to mix with the sap in the following spring, and afford nourishment to the buds and leaves. Hence, we may consider the young bud, like the embryo of the seed, to draw its first nutriment from matter previously secreted, and in part deposited in cells, and afterwards reabsorbed and applied to its destined use.

The bud, thus nourished in its early growth by the ascending sap, is more or less rapidly developed, and the tree soon becomes clothed with leaves. Of the changes in the *motion* of the sap when vernation occurs, we have already spoken, and have now to describe others which are effected in the *qualities* of that fluid. The first action of the leaves upon the sap is to throw off a large portion of it. The insensible perspiration of plants has been particularly investigated by Drs Woodward and Hales, and by MM. Bonnet and Guettard. Woodward found that a sprig of mint, weighing only 27 grains, imbibed, in seventy-seven days, 2558 grains of water: yet its weight was increased only 15 grains; and it must therefore have given off in that time 2543 grains of fluid. Hales calculated that a sun-flower, the area of the surface of which above ground was equal to 5616 square inches, gave off, by perspiration, in a warm dry day, about 20 ounces of fluid. In a warm dry night, without dew, it exhaled only three ounces. When the dew was sensible, there was no perspiration; and when the dew was abundant, or the night wet, then the weight of the plant was increased. The more succulent leaves perspired more than those of firmer texture, and deciduous leaves more than those of evergreens. In plants of the same species, and placed in similar circumstances, perspiration is proportional to the extent of perspiring surface: but in all plants, cold and humidity, more or less diminish or entirely suspend this function.

The fluid thus perspired was collected by Hales as it issued from the leaves of various herbs and trees. The liquor in all was very clear, nor could he distinguish any difference in its taste. It had nearly the specific gravity of water, but when exposed to a hot sun it began sooner to putrify. M. Senebier evaporated the perspired fluid of a vine: the *residuum* consisted of minute portions of resinous and gummy matter, and of carbonate and sulphate of lime, which ingredients seemed to augment as vegetation proceeded.

By the loss of its more aqueous parts, the proportions of the remaining ingredients of the sap must be much changed. Grew, Malpighi, Du Hamel, and others, have pointed out the great differences produced in the consistence, colour, odour, and taste of the sap during its transmission through the leaves,

—differences peculiar to each species of plants, and which have obtained for the sap, at this stage of its movement, the appellation of "Proper Juice." It is in this "proper juice," says Du Hamel, that the narcotic power of the poppy, the corrosive quality of the fig, the diuretic virtue of the fir, and the purgative property of jalap, resides: and even the peculiar products obtained from the sugar-cane and maple arise probably from the intermixture of the proper juice with the common sap: whence we may infer that the virtue of plants resides principally in their "proper juice."

It is difficult to collect these juices in a pure state. Those which have been examined differ much in their chemical properties. In some of them, mucus is the predominant ingredient, and such juices are generally mild and nutritious. Of the milky juices some are mild, others hot and acrid. From the "proper juice" of Euphorbia, M. Chaptal obtained, by the agency of chlorine, a white precipitate, consisting of two parts resinous matter and one part woody fibre. The juice of the *Carica papaya*, a tree that grows in Peru, yielded M. Vauquelin a substance very like the fibrine of animal matter. From other juices, gums, resins, turpentines, balsams, tannin, sugar, and various other products, have been obtained: so that, in their sensible qualities, these juices differ as much from each other as they do from the common sap; but all of them appear to contain a substance resembling in character the woody fibre.

That the difference of quality observed in the common sap and proper juices is effected chiefly in the leaves, seems now to be generally admitted. Some part of this difference is doubtless attributable to the concentration these juices experience from the exhalation of so much water; but a much larger part is to be ascribed to the effects which result from the combined agency of light and air. That air is essential to the vegetative process, and that the leaves of plants more especially act on the air, are positions long since established by decisive evidence; but physiologists are not yet agreed as to the nature and extent of this action; nor, consequently, as to the mode and degree in which it affects the vegetable fluids. This discordance appears to us to have arisen partly from imperfect experiment; and in part also from blending together two actions performed by the leaves, which, in their nature, are quite distinct; and which, though they commonly go on together, may be easily separated, and the peculiar and specific results of each better observed and estimated.

In the ordinary circumstances of growth, plants are exposed, at the same time, both to light and air; and each agent exerts on them peculiar and specific effects. If deprived of air, when in a state of active vegetation, plants not only cease to grow, but soon die; but the exclusion of light is not followed by suspension of growth, and still less by death. Hence, in favourable circumstances as to heat and moisture, plants continue to vegetate even through the night; and are frequently seen to grow in situations from which light is wholly excluded. They then lose, however, many of their peculiar and more active properties; but they augment in size, and display their specific forms. Air, therefore, is essential to vegetation; but light, though necessary to the developement of certain properties, is not essential to the growth of plants. It will be convenient, therefore, to consider the functions of the leaves, first, in relation to air; and, secondly, in relation to light.

The late Dr Priestley led the way in pointing out the nature of the changes which the air suffers in vegetation; but from not clearly ascertaining, at that early period, the composition of the air he employed, nor the extent of change it suffered, nor being fully aware of all the circumstances which might vary his results, he arrived at contradictory conclusions as to the effects which vegetation ultimately produces in the air. On the whole, however, he considered the atmosphere, when vitiated by other processes, to be purified by the growth of plants. His illustrious contemporary, Scheele, by previously removing the carbonic acid from the foul air he employed, found that plants, by their vegetation, either in sunshine or in shade, constantly deteriorated the air. Similar results, as to the deterioration of the air, in ordinary vegetation, were obtained in many of the experiments of Ingenhousz, Senebier, Woodhouse, and De Saussure; and they have since been extended and confirmed by Mr Ellis in the work already referred to. By these experiments, it is proved, that plants, like the seeds from which they have sprung, require, in the atmosphere in which they are set to grow, the presence of oxygen gas; that, by their vegetation, they convert this gas into an equal bulk of carbonic acid gas; and that the azotic portion of the air, as well in volume as in composition, remains unaltered.

As the seed, in its germination, supplied carbon to unite with the oxygen of the atmosphere, so does the plant yield that element for the same purpose, during its vegetation. Most vegetable substances, either dead or living, solid or fluid, when placed in suitable circumstances as to heat and moisture, deteriorate the atmosphere by forming carbonic acid gas: and the experiments of MM. Huber, Senebier, and De Saussure, show, also, that, when all the oxygen of the air has been consumed, they still yield carbon to unite with its other ingredient, so as to form carburetted azotic gas; or, if hydrogen gas has been employed instead of azote, then carburetted hydrogen is formed. Neither, therefore, the living state of a plant, nor the presence of oxygen gas, is essential to the separation of carbon from vegetable matter; and we may, therefore, presume that its separation is owing not so much to any attractive force excited by the gas employed, as to some spontaneous change in the vegetable compound itself, whereby its carbon is enabled to combine with the gases that surround it, in the order of its affinity for them. In low temperatures, or when the plant is very dry, its functions are more or less completely suspended, and the formation of carbonic acid is then proportionately reduced; while, on the contrary, a vigorous exercise of the vegetative powers gives rise to a corresponding production of that gas. In what state or form the carbon exists, at the moment of its combination with elastic fluids, is not yet known; but it is probably held in solution by water,

and acquires and retains its elastic state, only while in union with a permanently elastic body. It may farther be asked, in what part of the plant does this union of its carbon with the oxygen gas of the air take place? and in what manner is it accomplished? In the living plant, it is chiefly by the leaf that carbonic acid is formed. To discover the mode and place in which it occurs, we must take into view not merely the change produced in the air, but the structure of the living organ by which that change is effected; for it is only by combining a strict regard to anatomy with our chemical knowledge, that we can ever hope to arrive at true physiological conclusions, and avoid the crude and fanciful notions that have too often usurped their name.

The leaf, then, is formed of a vascular system, of cellular tissue, and of a cuticular covering that invests it on all sides. To this organ the sap is brought by vessels which spring from the alburnum or wood, and which, after forming several fasciculi in the petiole, proceed to the base of the leaf, and there, by their expansion and distribution, produce a minutely reticulated structure, With these sap-vessels, "proper vessels" are every where associated (§ 361), which appear to communicate with the sap-vessels, and to convey the sap they receive into the inner bark. Grew considered the vessels, which form the reticulations of the leaf, to be of the same size in every part, and never to inosculate or anastomose, except end to end, or mouth to mouth, after they have come to their final distribution. Malpighi, on the other hand, believed them to anastomose in every part (§ 8 and 9): and, in regard to the minuter transverse fasciculi, given off from the longitudinal bundles, he has been followed by Mr Todd Thomson, who, however, though he considers them as "distinct vessels, uniting with the longitudinal bundles in a singular manner," has never been able to determine "whether there is any opening directly into the longitudinal vessel on which the extremity of the transverse vessel is applied." It is during the course of the sap, through the two orders of vessels in the leaf, that it undergoes those changes in its properties which fit it for nutrition; but whether these changes are effected in the sap-vessels, or the "proper" vessels, or partly in both, has not yet been determined.

The minute network formed by the vessels is everywhere filled up with cellular tissue, constituting the parenchyme of the leaf. The cells of this tissue contain fluids derived from the neighbouring vessels, and are likewise the seat of the green colouring matter. There must, therefore, be a ready communication between the vessels and cells; and this many have supposed to be accomplished by the medium of pores in the sides both of the cells and vessels. But the best observers represent the cells as close cavities (§ 87 and 88), having no visible communication with each other. Were we even to admit the existence of pores, we should find it difficult to conceive how the contents of the cells could be set in motion and transmitted through their own sides, and those of the vessels also, so as to be conveyed and deposited in the several parts where growth takes place, with all the regularity we actually observe. To us no other means occur of accomplishing these operations, consistently with the integrity of the cellular structure, than the exercise of those alternate functions of secretion and absorption, which, from so many other considerations, we have supposed to be carried on in every vegetating part of the plant.

The cuticular covering of the leaf is the organ through which, under different circumstances, the fluids that are exhaled and absorbed must pass; and through which also both light and air exert their peculiar action on the vegetable juices. The structure of this organ has excited particular attention, and the opinions held concerning it have been detailed in § 138, &c. of our former article. It is there described as being composed of a proper cuticle, beneath which is a vascular network, the vessels of which, springing from the larger fasciculi, form at various points an oval ring, § 148, from whence go off two or more radiating filaments, which terminate at the cuticle in an oval pore, more or less elongated. It is by the vascular filaments, which thus terminate at the pores of the cuticle, that the exhalation of fluids is held to be performed; and hence it is, that, in different plants, this function is more or less abundantly carried on, in proportion to the number of cuticular pores (§ 77): and that plants, and parts of plants, which have but few pores, perspire little, and those that are destitute of pores not at all. Precisely the same coincidence between the number of pores in leaves, and their power of absorbing fluids, has also been remarked (§ 71 and 72): and we have elsewhere (§ 77 and 78) given reasons for coinciding in opinion with M. Decandolle, that the vascular pores, on the surfaces of the leaves and of porous stems, are the organs by which the functions both of exhalation and absorption are alternately carried on, according to the existing condition of dryness or humidity in the surrounding atmosphere.

Beside the function of exhalation, it has lately been maintained by Mr Todd Thomson, who has bestowed great attention on the structure of the leaf, that the pores are the organs by which the function of respiration in plants is performed. According to him, the pore is not a superficial aperture, but "a short cylindrical tube, penetrating completely through the cutis and terminating in a cul de sac, which is impressed into a vesicle that appears to communicate with the oblong cells immediately beneath the cutis. But although the aperture penetrates the cutis, there is no opening through the epidermis, which, on the contrary, enters into the tubular part of the pore, and lines it throughout." (*Elements of Botany*, Vol. I. p. 614.) In different leaves, the form of the pore, of its short tube, and of the vesicle beneath, are said to vary: but the cuticle or epidermis dips down and lines the cavity in all. By the funnel-shaped pore above described, the air is said to be admitted into the vesicle situated beneath it: and as this vesicle probably communicates with the cuticular cells, which are in general filled with air, the aqueous contents of the cells that form the parenchyme of the leaf, are thus brought into immediate contact with the atmosphere. (*Ibid.*, p. 622 and 623.)

If this account of the respiratory organs be received, then we must suppose, that, in herbs, respi-

ration is carried on by both surfaces of the leaves, but in trees, only by the under surface; for it is on those surfaces respectively that pores are found. It can hardly, however, be admitted that the existence of pores is indispensable to the production of that chemical change in the air which constitutes respiration; for, according to MM. Decandolle and Rudolphi, § 151, &c., the petals of flowers, the cuticle of fleshy fruits, the tunics of seeds, the stems and leaves of etiolated plants, most of the lower tribes of vegetables, and all roots and bulbs that grow beneath the soil, are alike destitute of pores; and yet the united experience of Priestley, Scheele, Ingenhousz, and De Saussure, bears testimony that all these parts are capable of acting on the air like porous leaves. Mr Thomson, indeed, states that some of the lower tribes of vegetables, and certain etiolated leaves, are really furnished with pores; but even granting this to be the case, there still remain other parts of plants, which grow beneath the soil, and yet act upon the air, like porous parts that vegetate on the surface. Without denying, therefore, the probability that porous surfaces, such as Mr Thomson describes, may favour the exercise of the respiratory function, we are compelled to admit that surfaces, not yet discovered to be porous, are capable of producing similar changes in the air. There is also an anatomical difficulty in Mr Thomson's view of this part of the respiratory function which we cannot readily get over; for while he describes the epidermis that lines the pore as having "no opening" in any part, he seems to think that the air passes to and fro, not only through this epidermis, but also through the cells of the parenchyme, which Hooke and others, from actual experience, declare to be impervious to air.

But whether, in porous leaves, the air enter the pores in order to be changed, or in leaves and parts not porous it be changed at their surface; or whether, by some unknown means, it permeate the cuticle, cells, and vessels, so as to act directly on the fluids they contain—it seems certain that these fluids acquire the properties, which fit them for nutrition and growth, directly through the agency of the air. How then does the air act in producing such effects? No specific action can be ascribed to its azotic portion, since that gas is not essential in vegetable respiration; and when present, it neither suffers nor produces any known change. Neither can we suppose the effects produced to arise from the loss of carbon, for were it proved that this carbon is extracted directly from the juices contained in the vessels, rather than afforded by the fluids they exhale, still the quantity given off is too minute to be considered as the cause of such remarkable changes; and it is more reasonable to believe that they proceed rather from something derived from the air, than from anything given off from the plant. They have accordingly been very generally ascribed to the *combination* of oxygen with the juices of the plant. Setting aside, however, the difficulty of conceiving how the oxygen can permeate the several textures of the leaf, so as to combine with these juices, it so happens, that the whole of that gas that disappears in vegetation exists, not in the plant, but exterior to it, and in union with the carbon afforded by the plant to form the carbonic acid gas produced in that process. Consequently, no part of the oxygen of the air can have combined with the juices of the plant; and, therefore, as far as the air is concerned, nothing remains but the caloric, extricated by the conversion of its oxygen gas into carbonic acid, to which these changes in the properties of the vegetable juices can be truly ascribed. How this caloric acts in the production of these effects, we do not, at present, undertake to explain.

Art. IV.—*Of the Mode in which the Proper Juice is applied to the Purposes of Growth.*

It is only after the common sap has been duly changed in the leaf by the agency of the air that it is rendered fit for the formation of vegetable matter. For this purpose, it descends in the "proper vessels," which in trees are commonly situate in the bark. If at this period, therefore, a circular portion of that texture be cut away, the proper juice is seen to issue from the *upper* lip of the wound; but this soon ceases, and its accumulation in the vessels then forms an enlargement around that part. Sometimes the proper juices exude, and form concretions of a gummy, saccharine, or resinous nature on the surface of the bark, and sometimes they are effused into the sap-vessels or cells. Where the bark is young and succulent, the juices receive probably some farther change in their descent; for such stems act on the air like leaves, and, in some species of plants, which are destitute of leaves, the functions of the leaves are performed by the stem alone. In ordinary trees, however, the bark is unable to form nutrient matter without the aid of the leaves, as an experiment of Hales distinctly shows. He removed circular portions of bark, half an inch in breadth, from a thriving branch of pear tree, so as to leave several ringlets of bark, three quarters of an inch distant from each other. All these ringlets, except one, had a leaf-bearing bud on them, and all but this one swelled at their bottoms and grew; and the more leaves the bud produced, so much more did the bark on which it grew swell at the bottom, while the leafless ringlet did not swell or increase at all. From facts before stated, it also appears, that a portion of the nutrient matter that descends from the leaves is found in the alburnum, as well as in the bark; and this will be still more clearly shown when we come to treat of the regenerating powers of the alburnum.

In discoursing on the trunk of trees (§ 274, 275), it was stated that a layer of bark, called *liber*, and a circle of wood, named *alburnum*, are annually formed; and that between this liber and alburnum the new matter that adds to the bulk of the tree is deposited, and becomes organised. Malpighi believed the *liber* to form the new parts, and that these parts were afterwards converted into wood. Grew also considered the new wood to be formed by the bark, but not that the liber was converted into wood. Hales, on the other hand, supposed the new wood to be formed by the old; while others have held that both bark and wood contribute to form new matter.

Are, then, the new layers which are annually added to the tree formed by the bark, by the wood, or by both? By very satisfactory experiments, which we have not room to detail, M. Du Hamel ascertained, first, that the bark is able to form new wood, and that this power resides not in its outer layers, but in the part called *liber*. Secondly, By another series of experiments, he ascertained that the *alburnum* is also able to produce new wood and bark, but that this power is not possessed by the older and more hardened vessels of the wood.

The process by which new vegetable matter is formed in trees is thus described by the same excellent writer. When a portion of bark has been removed from a tree, a glairy mucilaginous fluid is first seen to flow from beneath the remaining bark, or, in certain circumstances, from the alburnum. It differs in appearance from the proper juice, and was named *cambium* by Grew. To observe the process more completely, Du Hamel enclosed the stems of young elms and cherry trees, from which portions of bark had been removed, in glass tubes, closed at each end by cement. For a few days, the glass was obscured by vapour, which gradually disappeared; so that it was then easy to see what passed within. At first, a small tubercle appeared beneath the upper lip of the wound, and one still smaller at the lower lip. After this, granules of gelatinous matter issued from the alburnum: they were isolated, and had no connection with the tubercles just mentioned; their colour was at first greyish, but, in about twelve days, passed to a greenish tint. All these new parts continued to extend through the summer; the tubercle from the upper lip of the wound enlarged greatly, but that below, very little; so that it was principally by the growth from above that the wound was healed. The bark of the cicatrice having been formed by the union of new productions from the upper and middle part of the wound, was very rough, and in some places entirely wanting; but all the regenerated parts duly performed their appropriate functions, and the stems augmented so much as, in some instances, to burst asunder the glass tubes that enclosed them.

That the gelatinous matter or *cambium* that issued from the alburnum was not an extravasated mucilage, but a substance resembling the granulating matter by which wounds are healed in animals, Du Hamel inferred from observing that the process of regeneration went on, though more slowly, when the glass tubes were filled with water, which, as he supposed, would have dissolved simple mucilage. He likewise found, by other experiments, that the bark may be made to reproduce new parts from the sides or lower lip of the wound, as well as from the upper lip; that the new layer, annually produced, is made up of many others extremely thin, which envelope each other, and appear to be formed in succession so long as the sap flows; that, while roots extend only by the addition of new matter to their extremities, the young and succulent shoots of trees are elongated not only by the addition of new parts, but the extension of those already formed; but that this elongation, by extension, ceases as soon as the new ligneous parts become hardened. For a description of the mode in which, according to Du Hamel, trees augment, both in length and breadth, through all the successive years of their growth, we must refer to § 301 and 351 of our former article, and to the diagrams fig. 10, Plate XVII. and fig. 10, Plate XVIII. there given in illustration of it. Du Hamel farther ascertained, that the diametral growth continues in trees after that in length has ceased. Most of these facts have been confirmed by the experiments of Mr Knight, who found that the alburnum not only formed new wood and bark, as stated by Du Hamel; but that, when both the bark and alburnum were cut away, the more interior vessels of the wood were alike capable of yielding an organizable fluid; so that a vascular bark, capable of executing the ordinary functions of that texture, could be produced, in certain circumstances, by vessels lying deeper than the alburnum. Whether, in the ordinary growth of trees, the new matter is formed by the bark or the wood singly, or by both united, it is not easy to say; but it seems certain that, under favourable circumstances, each texture is capable either of adding to itself, or of reproducing the other. We have before remarked (§ 68) that, when the parts of plants have been once formed, they continue permanent, unless removed by accident or disease: that vegetables possess no power of removing decayed organs by *internal* absorption, as occurs in the animal system; but that their powers of regeneration are confined to the reproduction of parts or organs that have been removed by decay, by accident, or disease.

Art. V.—*Of the Changes the Sap undergoes in the Leaves from the Agency of Light.*

In what has hitherto been said, we have supposed the functions of nutrition and growth in plants to be carried on, as in seeds, by the combined agency of water, heat, and air, without the access of light. Light is injurious to the growth of seeds, by impeding that change of *fecula* into sugar, which is so favourable to germination: and that it also retards the formation of saccharine matter in plants, is proved by many facts familiar to every one in the cultivation of celery and other plants, which, when secluded from light, not only lose their colour, but acquire a mild, and even sweetish taste. If a plant, says M. Achard, be covered with a glass vessel, it is observed sometimes to change from a sweet to a bitter taste; but if the vessel be opake, the same plant, in its subsequent growth, will retain its sweetness. In the year 1774, the late Professor Robison observed, that tansey, mint, and other plants, which had grown in a dark coal mine, although they throve well in darkness, lost their colour, their odour, and their taste: But when they were brought up and set to grow in day-light, their white parts died down, and the stocks then produced the proper plants in their usual dress, and having all their distinguishing properties. When deprived of light, says Dr Irvine, all plants nearly agree in the qualities of their juices. The most pungent vegetables then grow insipid; the highest flavoured, inodorous; and those of the most variegated colours are of an uniform whiteness. Vegetables which grow in a natural situation, he adds, readily burn when dry; but a vegetable, bred in a dark box, contains nothing inflammable. The results of analysis accord perfectly with these observations: for etiolated

plants are found to yield more saccharine matter, carbonic acid and water, and less inflammable matter than those which are green.

From the facts above stated, it appears, that, when deprived of light, plants continue to grow: that the juices, which support this growth, are then nearly alike in all: and that they acquire their peculiar properties as to colour, odour, taste, and inflammability, only when vegetation proceeds under the direct influence of light. To the agency of the air, therefore, we may ascribe those changes in the vegetable juices, which render them fit for nutrition and growth: while light bestows on them those more obvious and active qualities, on which their colour, odour, savour, and combustibility more immediately depend. The first series of effects resembles those which are exhibited in the germination of seeds, from which process light is excluded; the second series is superadded to the former, and is directly attributable to light. It is on the leaves and succulent stems of plants that light chiefly acts; and it is in those parts that the "proper juices," which give colour and peculiar character to plants, more especially reside. Are we then able to trace out the mode in which it produces any of these singular effects?

In all periods of active vegetation, plants uniformly convert the oxygen gas of the atmosphere into an equal bulk of carbonic acid gas; and if, at the same time, they grow in obscurity, they soon lose their green colour and become white. On the other hand, if they be made to grow in impure air under exposure to sunshine, they not only resume their green colour, but occasion a production of oxygen gas. This curious discovery was first made by Priestley. It has since been extended and confirmed by the experiments of Ingenhousz, Senebier, Woodhouse, and Davy; and more lately the subject has been treated with still greater precision by M. De Saussure. From the united labours of these writers we learn, that air, which has been depraved by animal respiration or combustion, is again, in certain circumstances, rendered pure by the aid of plants: that the air, which experiences this purification, must contain a portion of carbonic acid, either in an elastic form, or held in solution by water, and that it must be exposed, with the plant confined in it, to the influence of the solar rays: that neither the plant alone, nor light alone, will effect the decomposition of carbonic acid gas, which is accomplished only by their united agency: that only the leaves and other *green* parts of plants are able, by this decomposition of carbonic acid, to produce oxygen gas: and that the bulk of oxygen produced in these circumstances is exactly *equal* to that of carbonic gas which has disappeared. Hence, if plants be made to vegetate in a given bulk of atmospheric air, and placed alternately in obscurity and sunshine, carbonic acid is successively formed and decomposed; so that, as M. De Saussure ascertained, the air suffers no permanent change either in its bulk or composition.

This operation of plants in purifying air was deemed by Priestley a *vegetative* function carried on by the aid of light; and by Ingenhousz it was ascribed not to vegetation, but to the influence of light combined with a certain state of vegetable structure. As plants grow in obscurity, where they produce no oxygen gas, this operation cannot be deemed essential to vegetation: and, on the other hand, the decomposition of carbonic acid is effected by the combined agency of plants and solar light, in situations and under circumstances where vegetation cannot exist. Thus, if plants be placed in sunshine, they produce oxygen gas either when immersed in vessels of water saturated with carbonic acid, or when confined in pure carbonic gas. So likewise a similar decomposition of this gas is accomplished by plants, with the aid of light, in temperatures many degrees below freezing, and in such a state of mutilation as is incompatible with the proper exercise of their vegetative powers. Hence, in these different instances, the decomposition of carbonic acid is effected by plants without the aid of that oxygen gas, or that degree of heat, or that condition of structure, which are essential to vegetation; while, on the contrary, it occurs only under exposure to light, which, as we have seen, is not necessary to vegetable nutrition and growth.

But the operation of light, which is thus necessary to the decomposition of carbonic acid, is required also to produce the *green colour* in plants; and exclusion of light, which prevents this decomposition, prevents also the appearance of that colour. The two effects, indeed, are not only accomplished by the same agents, acting in the same circumstances, but, as far as observation extends, are simultaneously performed: whence it may be inferred, that some necessary connection subsists between them; and, could we discover this, it might lead us to an explanation of the green colour of plants.

M. Senebier observed, with great care, the operation of light in rendering white leaves green. At first, yellow spots are seen, in different places, which gradually become deeper, and at length green. These spots multiply, extend, and meet on the face of the leaf, till at last it is rendered entirely green. If part of a white leaf be secluded from light, by covering it with tinfoil, that portion continues white, while the other parts become green: or, if a green portion be similarly covered, so as to exclude the light, it gradually loses its green colour, while the neighbouring parts retain it. From these and similar facts, M. Senebier considered the green colour in plants to be effected by the direct agency of light, independently of vegetation. He remarked, too, that a singular relation subsists between the parts of green leaves that furnish most oxygen, and those parts of white leaves which first become green: and from the circumstance of carbonic acid being decomposed and its oxygen expelled only when these parts became green, he was led to ascribe the green colour to the retention of the carbon of the decomposed gas, and its deposition in the cellular tissue of the leaf.

Granting, however, this deposition of carbon in the manner above stated, we know of no fact or analogy that lends probability to the idea that it is able to change the colourless juices of the leaf to a green hue. These juices are of a resinous nature, and may be extracted by alcohol without loss of colour; but this colour is then readily discharged by acids, and restored by alkalis; so that the action of these re-

agents on the green colouring matter of the leaf resembles that which they exert on ordinary vegetable infusions. Acids also discharge, more or less completely, the green colour of entire leaves, and alkalis more or less perfectly restore it. Since, then, the colouring matter of leaves, when extracted by water or alcohol, and even entire leaves themselves, are thus variously affected by acids and alkalis, may we not presume that the same reagents will exert a similar action on the juices of the living leaf, if acid or alkaline matter be made to predominate in them?

Now, that alkaline matter is an abundant ingredient in leaves is familiar to every one; and the observations of Hales, Du Hamel, Coulomb, Knight, and others, show also, that, in the ordinary growth of plants, carbonic acid is largely carried in with the sap, either in solution or in combination with alkaline matter. With the alkali already present in the leaf, the excess of acid carried in with the sap will readily combine, and according to the proportion in which acid and alkali are present, the leaf will be variously coloured. If the acid abound, as in etiolated leaves, the leaf will be white; but if means can be found to withdraw this acid, and render the alkali predominant, then the green colour will appear. "Now, the decomposition of carbonic acid in plants, by the agency of solar light, seems to be the mean employed by nature to accomplish this purpose; for by this mean," says Mr Ellis, "the acid is not only withdrawn from its combination, and its oxygen expelled, but the alkali at the same instant becomes predominant, and exists, therefore, in a state fitted to exert its specific action on the colourless juices of the plant, which, in consequence, are rendered green. The coloration of the leaf, therefore, is not owing immediately to the decomposition of carbonic acid and expulsion of oxygen, but to the predominance of alkali which that decomposition occasions. Hence, in the earlier stages of the process, we cannot so properly say that the green leaf affords oxygen, as that it becomes green when that gas is expelled; and thus it is that the decomposition of carbonic acid in leaves, by the agency of solar light, gives rise at once to the production of oxygen gas, and the formation of the green colour in plants."

But though light thus appear to be the active cause of colour in plants, yet, as it acts only by rendering alkali predominant in their juices, it follows that if, from the soil, or in any other manner, a similar predominance of alkali arise, these juices will be rendered green. Hence certain buds and the germs of some seeds, and parts which lie within the bark of certain herbs, exhibit a greenish hue, though perfectly secluded from light; so that it is not to be doubted, as Senebier remarks, that plants, and parts of plants, may become green, although light should not act immediately upon them.

If thus the predominance of alkali occasion a green colour, then deficiency of it, and still more, excess of acid, should have a contrary effect. Accordingly, when light is excluded from plants, no carbonic acid is decomposed in the leaf, and then its retention and accumulation, by saturating the alkali, subdue the green colour, and give rise to the white appearance observed in etiolated plants. So, likewise, the changes of colour which leaves exhibit in autumn seem to arise from the abundance of acid matter, not, however, occasioned by the absence of light, but developed under the various conditions of decay and decomposition in which they are then placed.

From the facts stated above, with regard to the alternate consumption and production of oxygen gas by growing plants, a question has arisen, whether, on the whole, vegetables purify or deteriorate the atmosphere. We cannot enter farther into this question than to observe, that it is not to be decided altogether by experiments made in close vessels of artificial mixtures of air; but demands a comprehensive survey of vegetation in different climes, and a knowledge of the times and circumstances in which the one or other process prevails, or is variously accelerated or retarded. Since, too, the production of oxygen arises solely from the decomposition of carbonic acid in the plant, we must also know the modes and quantities in which that gas is supplied to plants: for the power of plants to produce a large excess of oxygen, when confined in artificial atmospheres that contain from 7 to 10 *per cent.* of carbonic acid, does not at all apply to the natural condition of the atmosphere, which contains less than a thousandth part of that gas. We have already remarked, that carbonic acid is largely carried into plants with the rising sap; and various facts seem also to prove, that, when plants are confined in close vessels containing carbonic acid, that gas enters the leaf in an elastic form. Other gases, as oxygen, hydrogen, and azote, under similar circumstances, obtain admission also; and fleshy leaves, in particular, take up, through the night, a volume of oxygen greater in bulk than themselves, which, according to De Saussure, they again give out when exposed to a bright sunshine. It is not yet determined in what way elastic fluids thus obtain admission into leaves, and are again expelled from them; but the indiscriminate mode of their entrance and expulsion, at times, too, and under circumstances, in which vegetation is completely suspended; their long retention in a bulk greater than the containing body, and other circumstances, which we have not room to detail, lead to the belief that the phenomena are quite distinct from those which properly constitute vegetation, and are attributable to the conjoined operation of mechanical and chemical causes, aided by a certain condition of structure in the vegetable organs.

When, in the experiments of M. De Saussure, plants were made to vegetate in atmospheric air, and placed alternately in sunshine and in darkness, the decomposition of carbonic acid in the former case so exactly balanced its previous formation in the latter, that the air suffered no permanent change either in purity or in volume. Even in sunshine, continues the same author, plants, growing in close vessels, continue to produce carbonic acid, and it is only because they then also decompose it, that they do not permanently vitiate the air: hence, if a substance that attracts the carbonic acid as fast as it is formed be placed in the vessel, the air of the vessel no longer preserves its volume, nor its proportion of oxygen gas. Whether, in the free atmosphere, plants

also decompose the carbonic acid which they have previously formed, may well be doubted; but if they do, this adds nothing to its purity, but only restores what before had been taken away. And certainly, as the atmosphere at no time, whether vegetation proceeds or stands still, contains more than a thousandth part of carbonic acid, plants cannot, from that source, afford to it more than an equal portion of oxygen gas. As far, therefore, as the atmosphere is concerned, we believe that growing plants deprave rather than purify the air: but whether the decomposition of the acid gas, carried in with the sap, may not compensate, or more than compensate, for this depravation, we do not, at present, venture to decide.

Beside contributing to their *colour*, light, as we have seen, exerts a direct action on the substances that impart odour, taste, and combustibility to vegetables. These several qualities depend immediately on the oils, volatile and fixed—the resins, gum-resins, balsams, and turpentines—the alkalis and acids—the earthy and saline compounds—and the tannin, extractive, and other principles met with in the proper juices. It is probable that these substances are formed in the leaves and other corresponding structures, chiefly by peculiar secreting organs; but either the functions of the organs, or the products they yield, appear to experience great modifications and changes from the direct action of light; and hence, if this agent be wholly excluded, these vegetable products are either sparingly formed, or not at all produced. When formed, they become mixed with the sap in its course through the leaves, and variously change its sensible properties, so as to constitute juices proper to each species of plant. Thus blended with the sap, they are conveyed, more or less abundantly, through the organized parts, and impart to them those properties of colour, odour, taste, &c. observed in the several textures. Sometimes the gummy and resinous matters exude on the surface of the tree, or stagnate in the vessels or cells of the bark and wood—forming those collections and concretions met with in different parts of those textures, as described in § 63, 65, of our former article. All these ingredients of the proper juice serve, in vegetation, purposes different from those of the mucilage, starch, and sugar, from which the secretion called *cambium* is derived, and which is more immediately employed in the production of new vegetable matter.

In these operations of light on plants, it is probable that the several species of rays that compose the solar beam exert specific but varied actions. The violet rays, or rather the invisible rays associated with them, were observed by M. Senebier to act most powerfully in producing the green colour of plants; and he likewise ascertained that they act by their own peculiar quality, and not by their heating or illuminating power. This agrees with the acknowledged power of this portion of the solar beam in producing decomposition, since it is through the decomposition of carbonic acid in plants that their green colour is obtained. The experiments of De Saussure show also that by this decomposition of that acid gas, not only is oxygen gas expelled from the plant, but the proportion of its carbon increased; but whether this carbon contributes to the formation of any of the more active ingredients of the "proper" juices, or of those which impart colour; or whether the calorific power of the solar beam acts in their production, nothing yet known enables us to determine.

CHAP. II.

Of the Functions of the Individual Members and Organs of Vegetables.

Sect. I.

Of Buds, and of the Members and Organs produced from them.

Art. 1.—*Of Buds.*

Having thus exhibited a brief outline of the leading facts which constitute vegetation, as exemplified in the nutrition and growth of plants, we have now to notice, in a manner still more brief, the functions of certain parts and organs which serve different uses, and afford various products; and more especially those by which the continuance of their race is maintained. Some plants pass rapidly through the several stages of their existence, and having produced their seeds, fade and die; others continue for one or more years; and many prolong their existence to very distant periods. Even in these latter, the more active organs of vegetation, after producing their fruits and seeds, fade and fall like plants of shorter duration; and when the season adapted to the growth of *annuals* returns, then also *perennials* reproduce all the organs necessary to growth and fructification. In ordinary cases, reproduction in annuals is continued only by seeds; in perennials, both by seeds and buds. For an account of the species of buds, and of their formation and structure, we must refer to § 324 of our former article: at present we can afford space only for a few observations on those varieties of buds which produce branches, leaves, and flowers.

During summer and autumn, when perennial plants add to their bulk by the formation of new layers, they also form new buds on the sides and at the extremities of their branches. These buds continue to enlarge through the autumn, and in part through the winter; so as to be ready, on the return of spring, to shoot forth, and supply the place of those that annually decay. Some buds chiefly produce wood; others, leaves; others, flowers; and others, both leaves and flowers; and this variety of production may be so modified by culture as to enable us often to substitute one species of bud for another. The wood and leaf buds are the result of vigorous growth, and are primarily of the same structure. As the plant approaches to maturity, or when the vigour of its growth abates, then flower buds augment in number.

Buds naturally remain attached to the parent tree, and there execute their allotted functions: but they may also be made to grow as individuals, or be transferred, in various modes, to another stock, and perform the same functions on it, as on their proper parent. Though supplied then with sap from a different tree, they retain the power of effecting in that fluid the same changes, and forming with it the same

products as they would have produced on their native stock. The bud of the tree, therefore, like the embryo of the seed, must be held to possess individuality of character, and to be capable of producing new individuals perfectly similar to itself. To the embryo of the seed, however, as to every organized body, is assigned certain periods of infancy, maturity, and decay, which may be varied in duration from accidental causes, but can never, beyond certain limits, be changed. What is true of the primary embryo of the seed, is true also of all the buds propagated from it, whether they remain on the parent stock, or are transferred to another. Hence, when the period arrives in which the function of reproduction naturally ceases in the buds of the parent tree, all the buds, growing on foreign stocks, indicate the same character of age, and cease to bear fruit; and for the permanent continuance of the species recourse must then be had to a seminal progeny. Mr Knight has very ingeniously applied these principles to account for that failure in bearing fruit which the oldest and best varieties of trees in the cyder districts exhibit. Although grafts from these trees still grow on foreign stocks, yet they do not now yield fruit as formerly, because the trees, from which they have been taken, have outlived the fruit-bearing period.

Art. II.—*Functions of Branches, Thorns, and Tendrils.*

In its progressive growth, the bud, under its various forms, gives origin to Branches, with their various appendages of thorns and tendrils; of leaves and flowers. Of the structure of these several members and organs, an account has been given in § 292, 302, and 305, of our former article. The functions of the branch may be considered as similar to those already delivered of the trunk; which, indeed, it so nearly resembles in structure and growth, that, if cut off and planted, it readily, in many species, puts forth rootlets and buds, and becomes a perfect tree. Of the origin of branches from successive layers of wood, as explained by Du Hamel, a description has likewise been given in § 301.

The Thorns of trees may be regarded generally as abortive branches, which take on the form they bear chiefly from defective nutrition; and hence, as Malpighi observed, they often disappear under higher culture. Sometimes, however, they derive their origin from the degeneration of other organs, as from the stalks of leaves and flowers: they serve as a defence to plants, and protect them from the ravages of animals.

The several varieties of *fulcra* called Claspers and Tendrils have the same structure as branches; and originate sometimes, like thorns, from abortive leaves and flowers. Their obvious use is to connect the different parts of a plant with one another for mutual support, or to attach themselves, for the same purpose, to the bodies near them. Sometimes this purpose is assisted by means of a viscous secretion which they yield, and which glues them to neighbouring bodies with much force.

Art. III.—*Functions of Leaves.*

The Leaves spring from the buds chiefly of young branches, and by their number, forms, and colour, constitute the chief ornament of trees. If they exhibit less splendour than flowers, they enjoy a longer existence. They furnish to animals a large part of their subsistence, afford them shade and shelter, and spread everywhere beneath and around us, that "all refreshing green," on which the eye, fatigued and distracted by the glare of other colours, always loves to repose.

We have already discoursed largely of the functions of the leaves as organs of respiration and of transpiration. Besides this transpiring power, the leaves exercise also an absorbent function. From the experiments of M. Bonnet, it appears, that the leaves of many herbs, when laid upon water, absorb equally well by both surfaces, but those of trees only by the under surface: and these facts correspond with the observations of Decandolle and Rudolphi, as to the existence of pores on these surfaces respectively (§ 151). The power of the leaves to absorb moisture from the air was also abundantly proved in many of the experiments of Hales and Du Hamel, and more recently by those of Knight. This absorption appears to be carried on by the minute vascular terminations which open at the pores (§ 72); and is performed apparently by the same vessels, which, at a different time, and under different circumstances of temperature and humidity, execute the function of exhalation (§ 77). In thus ascribing to the terminations of these vessels the double capacity of exhalation and absorption, we do no more than what is allowed by all to be performed by the vessels of the branch from which they originate; for, when a branch has been separated from the trunk, and set to grow in an inverted position, the functions of its vessels, in relation to exhalation and absorption, become inverted also.

Beside the aqueous fluids given off by leaves, others are sometimes afforded, which seem to be secreted by peculiar organs. On the leaves of different plants, mucilaginous, saccharine, resinous, or oily fluids are sometimes seen; or if invisible by the eye, they are often sensible to taste and smell. In some leaves, these secretions appear to proceed from minute glandular organs, seated in the cellular tissue: in others, small follicles in the cuticular texture seem to afford them. Of the structure of these minute organs little is known, and still less of the mode in which they execute their functions. Of the influence of light on the secreted fluids of the leaf we have already spoken; and also of the mode in which it contributes to the production of its green colour. M. Bonnet has likewise shown that light exerts a great power over the motion or direction of leaves, of which some notice will be taken hereafter.

Art. IV.—*Functions of Roots.*

So nearly does the root agree in structure with the trunk, that, as Malpighi observes, we may consider it as a production of the trunk beneath the soil. From the principal root or stock proceed the buds that give origin to the primary rootlets; and these give off finer ramifications, which are the true absorbents of the root. These fine absorbents take

up the nutrient matter from the earth, and convey it to the root, from whence it is sent to the trunk. Where these absorbents extend, the earth is exhausted of its nutrient matter, and not in the neighbourhood of the larger roots. In a severe winter, Du Hamel found these fine rootlets to die, and to be abundantly replaced by others, when the temperature became milder. Not only the root, but the branch of a tree, readily produces rootlets, if it be amputated, and set to grow in water or in soil. The form of the root is much influenced by the texture of the soil. If the soil be easily penetrable, the root descends in the form of a long tap-root; but if it be hard and resisting, then the root remains shorter, and divides into lateral branches. Du Hamel remarks too, that roots extend into that portion of soil which is richest, while the barren parts are nearly destitute of them; so that the qualities of the soil, as well as its texture, exert the greatest influence on their direction and growth: in regard, however, both to composition and texture, different soils are best suited to different kinds of roots. We have before remarked, that the elongation of roots and rootlets is made by the addition of new matter to their extremities, not, as in succulent branches, by the simple extension of parts already formed. The diametral growth of roots is effected, like that of the trunk, by the formation of new layers between the bark and wood.

Art. V.—*Functions of Flowers.*

Flowers may be regarded not only as the last, but the most elaborated organs of the vegetable system. Whether we contemplate the beauty of their forms, the splendour of their colours, or the delicious fragrance they everywhere breathe around us; or whether, with a physiological eye, we survey the delicacy of their structure, and investigate the peculiar functions they perform, we cannot but feel the greatest admiration of the skill with which, in a compass so small, and by means apparently so simple, such a series of actions, terminating in results so varied and important, can at once be combined and regulated.

The flower is attached to the plant that bears it by the peduncle, on the extremity of which is placed the cup or calix, which, in its turn, supports the corolla, and the organs of reproduction. Of these organs, the male parts consist of one or more stamens, formed by the filament, bearing on its top the anther, which contains the fecundating particles, named pollen. The female organs consist of one or more pistils, the style of which bears on its top the stigma, and terminates below in the ovary, that contains the rudiments of the seeds. For an account of the structure of these several parts, see § 366 of our former article.

Various as are the forms, colours, and functions of the several parts of the flower, yet, in structure, they are so similar, that, under a change of circumstances, almost any one part or organ can be made to assume the character of any other. Thus, not only are the petals of the corolla, or the stamens and pistils, sometimes abortive; but, at other times, the stamens become simple filaments or petals, or the petals take the form of stamens. Sometimes, again, the style of the pistil changes into a petal: in other instances, the petal becomes a floral leaf, or the calix is changed into real leaves. In like manner, too, as leaves, or their petioles, are sometimes transformed into claspers and tendrils, so the peduncles and petals of the flower now and then exhibit similar transformations. Nor are these transformations confined to the leaves and flowers: they extend to the more solid and permanent members of the plant. Thorns, we before remarked, were but abortive branches: and as a branch, by surrounding it with earth, may be made to throw out rootlets instead of buds, so a root, when brought into light and air, will, on the contrary, put forth buds. Even an entire tree may be inverted, and the roots and branches, by being placed in circumstances respectively opposite to their nature, may be made gradually to assume each other's character, and execute each other's functions. These facts demonstrate a great uniformity of structure in all parts of vegetables, and show with what facility modifications of form and of function are induced, by varying the application of those external agents and conditions, concerned in the developement of vegetable organization.

1. *Colours of Flowers.*—The *colours* of flowers are not less diversified than their forms. They present every variety of tint and every shade of intermixture; and not unfrequently the same flower, at different times, or even at the same time, exhibits great diversity of colour. Grew remarked that no flower has its proper colour in the bud; that many of them are then pale or white; and that the full and proper colour is formed only when they expand. Even after their expansion, the colour of some flowers, as that of the rose, may be made to disappear by secluding it from light, as Sir Humphry Davy remarked; and the flower of honeysuckle, which continues white while the light is excluded, acquires its red hue on exposure to light and air. In what manner, then, do light and air contribute to the coloration of flowers?

It has been long known that the colourless infusions obtained from flowers are variously affected by chemical re-agents. Grew, Becker, Geoffroy, Lewis, and Delaval, extracted from various flowers, both by water and alcohol, a colourable matter, which, on the addition of an acid, became red; and then by an alkali was made to pass into violet, blue, or green. The changes of colour thus produced in the infusions of flowers were also exhibited by the petals themselves, when immersed in acid and alkaline liquors; so that the existence of a colourable matter in flowers, capable of exhibiting a great diversity of tint, according as acid or alkaline matter is made to predominate, cannot be doubted; and in this respect the facts which regard the coloration of flowers coincide with what has been delivered concerning the colours of leaves. Many leaves, indeed, possess naturally a red tint, others yield to water different shades of yellow and red; and in autumn, almost all leaves commonly exhibit some variety or combination of those colours; so that, as Grew observes, "the colours of most flowers are begun in the leaves, only green being therein the predominant colour, as a veil spread over them, conceals all the rest."

In leaves which yield oxygen gas in sunshine, we have seen that alkaline matter is rendered predominant by the decomposition of the carbonic acid previously combined with it; but the united experience of Priestley, Scheele, Ingenhousz, and De Saussure, goes to prove that flowers never, under any circumstances, afford oxygen gas by the agency of light. In flowers, therefore, no carbonic acid is decomposed. Consequently, no predominance of alkali can be looked for; and, therefore, although flowers contain juices which are readily rendered green by alkalis, yet in them no green colour is produced.

Although flowers, which bloom in the shade, are paler than those which grow in light, yet, says Du Hamel, as their different parts are commonly coloured in the interior of the bud, light is not so necessary to their coloration as to that of leaves. From an experiment of M. Senebier, it would seem that, in some flowers, air contributes to the production of their colours; for he found that the petals of the rose, which had been whitened by digestion in alcohol, recovered their red hue when confined in vessels of common air, but not in those of azotic gas. Now, experience shows, that flowers, both in sunshine and in shade, uniformly convert the oxygen gas of the air into carbonic acid: and if this acid gas was retained in the vessel, it is probable that it contributed to restore the red colour of the petals, which restoration did not take place in azotic gas, because no carbonic acid was then formed. Perhaps, in the ordinary circumstances of growth, less alkali is carried into the flower than the leaf, and, therefore, the acid, that enters with the sap, will more readily contribute to its coloration; for as none of it is decomposed by light, it must be considered to abound in the juices of the flower. Hence, while in leaves, the green colour proceeds directly from the predominance of alkali, occasioned, as we suppose, by the decomposition of their carbonic acid; in flowers, where no such decomposition occurs, the retained acid acts either in destroying colour, as in etiolated plants, or exists variously in excess, and gives rise to those several grades of colour, from whiteness up to perfect redness, which different flowers exhibit. How far light may act in modifying the composition of those juices, on which the colours of flowers seem to depend, has not been sufficiently ascertained.

It is, however, probable that the chemical condition of these juices themselves, or the textures by or through which their colours are reflected or transmitted, are modified by variations of structure in the organs, which altogether escape detection, and become known only in their effects. Du Hamel considered many varieties of colour in the flower to arise from the intermixture of different species and varieties of plants, at the period of fecundation. Poppies and primroses, which grow wild in our fields, are respectively red and yellow; but the same plants, transferred to our gardens, furnish a prodigious number of varieties. If the wild variety of primrose be removed from its natural place, and set to grow among cultivated varieties of the same kind which possess different colours, the seeds obtained will produce many yellow flowers, because the parent plant will have been fecundated by some of its own stamens; but it will also afford other varieties, because some of the seeds will have been produced by fecundation of neighbouring plants. Many of the fine varieties of flowers which Florists procure by means of seeds, seem to be thus obtained. They, indeed, attribute them to some particular infusion with which they have watered their seeds, or to some colouring matter they have mixed with their soil; or even to some differently coloured bodies they have presented to their plants, or to a singular good fortune peculiar to themselves. "I have tried without success," says Du Hamel, "these infusions and these mixtures of colours; and I deem it unnecessary to resort to experiment to destroy the two other means." In the ultimate production of colour, modifications may also proceed not only from the texture of the parts, but the configuration of their external surface, as exemplified in the prismatic tints of "mother of pearl," which, according to the beautiful observations of Dr Brewster, owe their existence to the configuration of the surface alone.

2. *Odour of Flowers.*—Next to colour, the property in flowers that most strikes our senses is their odour. Other parts of plants, indeed, possess odour; but the finer and more diffusible fragrance that emanates from them proceeds commonly from the flower. Of the peculiar organs in flowers which form and emit odorous particles but little is known. Their ordinary seat is probably in the *corolla*, since many flowers, which are wholly destitute of sexual organs, emit their peculiar odours. Of the nature of the odorous matter, all we at present know is, that it is inflammable: and this property, M. De Saussure considers to depend rather on the presence of an essential oil, than on any variety of hydrogen gas. That light is more especially concerned in its production seems probable from the fact, already stated, that the most pungent odours cease to be formed in plants which are kept secluded from light; but are speedily produced in them when restored to its presence. In climates, too, and situations where the sun exerts the greatest influence, plants possess the most exalted odours and the most active inflammable ingredients: but of the mode in which the solar rays act in thus contributing to produce odour and inflammability in plants, little is at present known.

3. *Savour of Flowers.*—Connected with the odour of plants, at least in the mode of its production, is the property they possess of imparting sensations of taste. This property is more generally distributed through the vegetable, and is of a much less fleeting and diffusive nature than that of odour. Tastes have been regarded either as simple or compound; and of each a great diversity is to be found in plants. Tastes differ also in quality, degree, and duration; are more or less fixed or diffusible; and, in some instances, affect variously the different parts of the organ which receives the impression. Of all these, and some other varieties, examples are given by Grew, taken from the savours of the juices found in the wood, bark, and root; or in the leaves, flowers, and fruits of various plants.

In general, however, the roots, and all those parts that are secluded from light, have a taste milder and

less intense than others: and, as we before remarked, plants, possessing naturally a hot or bitter taste, become mild, or even sweet, by the exclusion of light, and resume again their pungent and acrid qualities if brought into day. Light, therefore, exerts a direct action in the formation of the savours as well as of the odours and colours of plants. The odour and savour are commonly more concentrated in some parts than in others; and when formed in the leaves, they are frequently mixed with the "proper juices," and more or less pervade every part of the plant. Although, therefore, the action of light, in the production of colour, odour, and savour, be, in the first instance, *local*, or confined to those plants, and parts of plants, exposed directly to its influence, yet these properties may afterwards be diffused, by the motions of the fluids, through all parts of the vegetable, including even those buried beneath the soil, and thereby protected from the action of light. From the whole it appears probable, that all the effects, simultaneously produced in plants by the direct agency of light, are, in position, local; in operation, chemical; and in nature entirely distinct from that series of actions accomplished by the air, and which contribute to their evolution, nutrition, and growth.

4. *Fecundation of Flowers.*—Although in appearance the flower differs so much from the leaf, yet, in structure, it is very similar; and, for the due performance of its proper functions, not only requires the presence of the same agents, but acts in the same manner upon them. The necessity of air to the growth of plants, and the conversion of its pure part into carbonic acid by the leaves, in every stage of that growth, have been already noticed; and Priestley, Scheele, and Ingenhousz, showed that flowers, in like manner, require air, and convert its oxygen into carbonic acid. M. De Saussure has since ascertained that flowers do not develope in atmospheres destitute of oxygen gas; that, in proportion to their bulk, they consume more oxygen than leaves; and that the oxygen that disappears is replaced by an equal volume of carbonic acid gas; so that little or no variation of bulk occurs in the air employed. Unlike leaves, however, flowers do not produce oxygen gas in sunshine. Under such an increase of temperature, they consume even more oxygen than before; but no trace of the production, either of hydrogen or azote, is discoverable in the atmosphere in which flowers have been made to grow.

Connected immediately with the great consumption of oxygen by flowers is the high temperature, which some of them manifest at the period of fecundation. MM. Lamarck and Senebier observed the flower of *Arum cordifolium* to impart the sensation of heat to the touch; and to possess, a little after mid-day, a temperature 12° higher than that of the surrounding atmosphere. In the Isle of Madagascar, M. Hubert found the same plant to raise the thermometer still higher; that the male parts of the flower possessed, in this respect, greater power than the female, so that twelve stamens, placed round the bulb of a thermometer, raised it, at the moment of bursting, from 70° to 121°; that this power resided in the exterior surface, not within the substance of the organs; and, lastly, that air was necessary to this elevation of temperature, and was rapidly depraved in the process. In confirmation of these facts, M. De Saussure has since found that double or imperfect flowers consume less oxygen than those which are simple and perfect; that the greatest portion of this gas is consumed at the period of fecundation; and that the stamens, adhering by their base to the receptacle, consumed more than other parts. He farther ascertained that the temperature of many flowers rises in proportion to the quantity of oxygen consumed; and, to the rapid combination of oxygen gas with the carbon of the flower, he ascribes, with M. Senebier, the great rise of temperature that occurs, in certain flowers, at the period of fecundation.

This necessity of air to the developement of flowers, taken in connection with the chemical changes it suffers, and the high temperature thence arising at the period of fecundation, points to some peculiar action which it exerts in the exercise of the generative function. Not long after the true nature and use of the sexual organs had been made known by Grew, Dr Blair, in a learned essay on the *Generation of Plants*, maintained, that, while the greater part of the ascending sap passed on to the leaf, a portion was also carried to the petals of the flower, and, in its course through them, underwent that change and elaboration which fitted it for forming the pollen, and rendering that matter the proper means of fecundation. A similar opinion of the use of the corolla was held by Du Hamel. The petals, says he, are organs necessary to fructification. They not only protect the stamens and pistils, but perform the office of leaves, in acting on the fluids of the sexual organs, and perhaps effect in them some important preparation. Dr Darwin, too, considered the petals to act, by the agency of the air, in elaborating the juices destined to nourish and develope the sexual organs. These views assign to the less important parts of the flower functions essential to the perfection of the whole, and corresponding in nature with those executed by the leaves, only that "Nature," as Grew observes, "hath lapped up the virtue in leaves as in brown paper, but in the flowers as in leaf-gold."

When the organs of reproduction have attained their perfect state, and a suitable condition of the atmosphere prevails, the process of fecundation is accomplished by various modes in different plants. By the agency of the solar rays, aided probably by that high temperature which, at this period, they derive from the decomposition of the air, the anthers burst and discharge the pollen in the form of a fine dust. This dust, in some instances, falls directly on the stigma of the pistil, previously prepared, by the secretion of a viscid matter on its surface, to receive and detain it. In other instances, the pollen is conveyed to the stigma by insects, or by the wind; and in others, its conveyance is accomplished in different modes. When the pollen has been shed, the stamens and petals soon begin to fade and fall; the filament of the pistil likewise fades; but the ovary at its base augments in size, and the pulpy globules, or vesicles, previously formed within it, enlarge, and as-

sume gradually the form and character of the perfect fruit or seed. For an account of the successive appearances exhibited in the formation of the seed, as observed by Malpighi and Grew, we must refer to § 383, 384, &c. of our former article.

The pollen, which occasions these extraordinary changes in the ovarian vesicles, is composed of small particles, which possess a different colour, size, and figure, in different plants. These particles are organized, and, when observed in a bright sunshine with a microscope, may, in some plants, be seen to burst; and then a liquor like saliva escapes, in which, says Du Hamel, small particles are obscurely visible. Of the chemical nature of the pollen little farther is known, than that it yields a peculiar matter, called *pollenin*, which is described as being of a yellow colour, without taste or smell, insoluble in water and alcohol, but highly inflammable, and yielding, by distillation, a good deal of ammonia, which approximates it, in composition, to animal matter; but this knowledge gives us no insight into the nature of its peculiar action.

It is also difficult to determine whether the pollen, after being received on the stigma, is conveyed so as to act directly on the ovarian vesicles, or whether it excites in them its specific action, without being brought into actual contact. In many plants, indeed, the number of pistils corresponds with the number of seeds produced; but in other plants, many seeds are produced, where there is only one pistil. Whatever be the form of the pistil, its opening, says Du Hamel, is often continued to its base, or even into the ovary: in other instances again, this opening is not visible. In the open pistils, a fasciculus of vessels extends probably from each division of the stigma, to each cell of the ovary. In the apple and pear, whose fruits contain five cells, and in which there are as many pistils terminated by their proper stigmata, each style, if dissected, is seen to divide into two below, so that a portion is continued to each seed: and in like manner, he continues, a single style, after entering the ovary, may divide into as many parts as there are cells for seeds. But whether the pollen act directly or indirectly on the ovarian vesicle, there is little doubt but its influence is necessary to the perfection of the seed: for though, as Ray observed, some fruits may be produced without the concurrence of the male parts of the plant, just as some birds will produce eggs without the concurrence of the cock, yet such fruits, like such eggs, are altogether barren and unproductive.

To the impregnation of one species of flower by another of a kindred nature, through the agency of winds and insects, Du Hamel ascribed most of the varieties of fruits denominated new. In some fruits, the species, in the hybrid production, are kept so distinct, that we are able to distinguish one part from another, with which it had been associated at the period of fecundation. Thus, there is a species of orange, which, on the same tree, says he, produces "des bigarades, des citrons, and des balotins séparés, ou même rassemblés par quartiers dans le même fruit." In like manner, a certain species of vine produces, on the same shoot, bunches both of red and white varieties; or on the same bunch both red and white grapes; or bunches on which the grapes are red and white by halves, or even by quarters. These diversities in fruits he attributed to the impregnation of one species by the pollen of another; and to a similar cause, as we before stated, he ascribed many of those diversities in the colours of flowers, where different varieties grow and blossom together. Others have made many direct experiments on the reproductive function in plants by *crossing* different species with each other; and, by a judicious extension of the same methods, Mr Knight has been able to present us with several new and improved varieties both of seeds and fruits.

Art. VI.—*Maturation of Fruits.*

The period that intervenes between fecundation and that in which the ripening of the fruit or seed is completed, varies in different plants, and even in the same plant, is much modified by climate, season, habit, &c. Whatever, to a certain extent, diminishes the vigour of vegetation, favours the production and accelerates the maturation of the fruit. So long as trees continue to shoot and abound in sap, says Du Hamel, their fruits do not arrive at maturity. By stripping them of their leaves, we hasten this period, not so much, however, by exposing the fruit to the sun, as by weakening the flow of the sap. But if the tree be stripped before the fruit has reached its proper size, both its size and quality are bad. As the powers of vegetation decline, the fruit advances towards maturity; and then exposure to the sun, by promoting transpiration and concentrating the juices of the fruit, hastens the ripening process. At an earlier period, however, the same degree of exposure, by exciting too great transpiration, might cause the fruit to languish and wither. When fruits are enclosed in bags to protect them from wasps, transpiration is checked, and the fruit enlarges; but has not so good a flavour as usual. The present taste for what are called "fine fruits," seems directed chiefly to size, and is content to resign the rich and racy flavour, found only in fruits of a moderate bulk, for the pampered and bloated produce of a too luxuriant vegetation.

M. Ingenhousz formerly maintained that fleshy fruits, whether ripe or unripe, and whether growing in sunshine or in shade, always vitiated the air in which they were confined: and in a late *Memoir on the Maturation of Fruits*, M. Berard has adopted the same opinion, and maintained, that green fruits do not decompose carbonic acid and disengage oxygen gas in sunshine, but that, through every period of their growth, they uniformly convert the oxygen of the air into carbonic acid gas. To this *Memoir*, M. De Saussure, who had formerly combated the opinion of Ingenhousz, has replied by new experiments; and has satisfactorily proved, that although, during the night, green fruits convert the oxygen gas of the air into carbonic acid gas, yet that, when exposed to sunshine, they again reconvert this carbonic acid into oxygen gas; so that, if they be placed alternately in sunshine and in obscurity, for two entire days, the air of the vessel undergoes successive changes which nearly counterbalance each other, and at the close of

the experiment no other degree of change exists in it, than may be attributed to errors of observation. Hence it is inferred, that, both in the shade and in sunshine, green fruits act upon the air like green leaves; but this action is carried on to a smaller extent, and diminishes as they approach maturity.

As thus the air, under similar circumstances, suffers the same changes from green fruits as from leaves, it may be presumed that the fruit owes its green colour to the same action of light upon it. Light seems also to act in the production of the other colours which fruits exhibit. M. Bonnet shut up, in cases of white tin, grapes of a black colour, which did not then acquire their natural hue. Pears, says Du Hamel, which grow in the shade are often green, while others, exposed to the sun, are beautifully coloured: and the same things are observed in peaches. Neither peaches, pears, nor cherries, assume their proper colours, if, at the period of ripening, says M. Senebier, they are secluded from light; and if a portion of fruit be covered with tin-foil, that part will continue pale or yellow, while the uncovered portions of the same fruit become perfectly red. If the red juices of fruits be extracted by water or alcohol, they are affected by acids and alkalis like those of flowers; and similar changes are produced by these agents on the coloured infusions obtained from their skins. These facts show that the same chemical actions, which occasion the colour of leaves and flowers, are employed in the coloration of fruits: but in these latter, they are probably much modified by the chemical changes that go on in the fruit itself during the process of maturation.

To discover the chemical changes that take place in the fruit during its maturation, M. Berard analyzed several fleshy fruits at different periods of their growth. With this view, three apricots of the same size were selected, and being plucked in succession, one of them was analyzed at three different stages of growth,—viz. in its green state, in a state more advanced, and in a ripe state.

The several results are given in the following table:

Apricot very Green.		Advanced.	Ripe.	
Animal matter...	0,76	0,34		0,17
Green colouring matter.........	0,04	0,03	Yellow	0,10
Woody fibre......	3,61	2,53		1,86
Gum	4,10	4,47		5,12
Sugar	traces of	6,64		16,48
Malic acid........	2,70	2,30		1,80
Lime...............	a very small portion in the three.			
Water............	89,39	84,49		74,87

In the interval between the first and last analysis, the fruit had so much increased in size, as nearly to double its weight. It will be seen that, with the exception of the green colouring matter, which had become yellow, all the ingredients, found in the unripe fruit, were present in the ripe one, but some were in greater proportion. Sugar in particular had greatly increased, and water had diminished. From these results it is inferred, that the different flavours of green and ripe fruits are not owing so much to the disappearance of any primary ingredient, or its transformation into another substance, as to the production of new substances, and especially of sugar, made in the progressive stages of growth. Similar analyses of cherries, gooseberries, plums, and peaches, afforded the same results.

There are some fruits, however, as those of apple and pear, which ripen very well after they are detached from the tree; and in these, sugar seems to be formed out of the other ingredients, as it is formed from fecula in the germination of the seed. M. Berard plucked a pear from the tree when firm and green, and shut it up in a close vessel of atmospheric air from the 12th to the 29th of August. Its colour had then become yellow, and it was perfectly ripe. During this period, its total weight had diminished very little, and this was due to the loss of a little water, and a minute portion of carbon; but the proportions of its ingredients were much changed, for the quantity of sugar was nearly doubled, and that of gum, of water, and of woody fibre, had decreased. The united loss of the gum and woody fibre were not, however, equal to more than half the gain of sugar; and, therefore, M. Berard supposes that water may have become fixed, and augmented the proportion of this latter substance. If water be thus held to have contributed to the production of sugar in the pear, we may suppose it to have served a similar purpose in the ripening of the apricot; for the loss of water in the ripe apricot, as compared with the green one, comes near to the gain of sugar; and no change in the relative proportions of the other ingredients can be deemed sufficient to account for the great increase of saccharine matter.

The external agents required to effect these chemical changes in the maturating fruit appear to be heat and air. In the above experiment with the pear, the vessel was kept in a temperature of about 82° Fahrenheit; and the air, as well as the fruit, underwent a change of composition. It remained, indeed, unchanged in volume; but 100 parts of it yielded, on analysis, 13·52 carbonic acid, 7·51 oxygen, and 78·97 azote: so that, as in other cases, the loss of oxygen was supplied by an equal bulk of carbonic acid, since the united volumes of the acid gas and oxygen made together almost exactly the $\frac{21}{100}$ of oxygen gas which the air at first contained. Hence no oxygen can have combined with the fruit; nor can the azote of the air be deemed to have undergone any necessary change, since the very minute portion of that gas unaccounted for may fairly be set down to error in experiment.

That this conversion of oxygen gas into carbonic acid is necessary to the maturation of fruits, M. Berard inferred from the fact that the process is arrested if fruits be kept in an atmosphere destitute of oxygen; yet, after being kept for some weeks in such an atmosphere, the process recommences if oxygen be supplied. In this production of saccharine matter through the entire substance of the pear, nothing can be attributed to the mere loss of the carbon and water which it gives off, and which to-

gether caused in it only a minute loss of weight; neither can we ascribe it to any combination of oxygen, since all the oxygen that disappears exists, exterior to the fruit, in the form of carbonic gas. Nothing, therefore, remains to explain the use of the air in this process but the liberation of caloric which takes place when its oxygen is converted into carbonic acid gas. To the action, therefore, of this calorific power on the gum or mucilage of the fruit, and perhaps on its water, must we chiefly attribute the change that constitutes maturation.

That caloric, in combination with moisture, will produce saccharine matter in fruits, as well as in seeds, is familiarly known in the ordinary process of baking pears, and was more precisely ascertained by Dr Darwin. He placed some pears, of a very austere taste, in an earthen vessel, and covered them with a few inches of water. The vessel was then placed in an oven. In nine hours, the pears had acquired a sweetish taste, and in twelve more had become nearly as sweet as syrup or treacle.

To this process of maturation, light, though ordinarily present, and acting on the colours of fruits, does not seem necessary; for fruits will ripen in dark places; and, to hasten maturation, it is not uncommon to enclose bunches of grapes in black bags, which must, at the same time, exclude light and accumulate heat. Whether light be actually unfavourable to the formation of sugar in fruits, as it appears to be in seeds, remains to be ascertained; but certainly, though it should retard, it does not prevent maturation; and its presence is ordinarily accompanied with such an increase of temperature as may more than compensate for its supposed injurious operation. Since, also, the vegetating process gradually diminishes as the fruit approaches maturity, and ceases to act upon it when its growth is completed, we cannot ascribe the changes that constitute maturation to vegetation, but must regard it as a chemical change, effected by the reaction of the several ingredients of the fruit on each other, under the operation of those external agents necessary to its occurrence.

Art. VII.—*Fecundity of Vegetables.*

The period required for the accomplishment of those changes in the ovarian vesicles, which terminate in the formation of perfect seeds, varies much in different species of plants, and also in the same species, under different circumstances of climate, soil, habit, &c. When they are completed, the ovary or pericarp, in which the seeds were contained, is opened, in various modes, for their discharge: or the fleshy pulp that invested them decays; or the stony covering in which they were imprisoned is rent asunder; so that, in one way or other, they are set free, and by various means are disseminated over the surface of the earth, destined either to reproduce new beings similar to themselves, or to minister to the gratification and sustenance of animal life.

Of the seeds thus produced, the number, size, figure, texture, and other properties, are infinitely diversified. With respect to their number, we have already, in our former article (§ 235), given examples of the productiveness of wheat and barley, and described the peculiar structure (§ 233) by which, in the family of the grasses, this productive power may be almost indefinitely augmented. M. Dodart prosecuted the same inquiry on trees. He selected an elm, which, in the fifteenth year of its growth, he calculated to produce, in one season, 329,000 seeds. Supposing this tree to live 100 years, and its mean fecundity, for its whole life, to be taken at 329,000, this number, multiplied by 100, will give 32,900,000 as the number of seeds produced, through its whole life, by the single seed of an elm. But suppose farther, says Du Hamel, all these seeds to be planted, and each to produce a tree as fruitful as its parent, and so on from generation to generation,—then, calculating the produce of each of these trees during 100 years, we shall have an increasing geometrical progression, of which the first term will be one—the second, thirty-three millions—the third, the square of that number—the fourth, its cube; and so on to infinity—a fecundity, which, in the revolution of ages, would be sufficient to cover the whole surface of the earth with one species of plant.

But propagation by seeds is not the only mode by which plants are multiplied. With the exception of some trees, as the pine and fir, which do not shoot afresh when they have been lopped, except when very young, most vegetables, continues the same author, contain in all parts of their branches, their trunk, and even roots, germs which do not develope unless rendered necessary by the retrenchment of their boughs. Thus, if an elm be headed, and its smaller branches removed, its trunk and larger branches will, in the following spring, be covered with new productions, which never would have appeared if the first branches had not been removed. At whatever part or height the tree is headed, new shoots spring forth. The whole tree, therefore, from the root to the extremities of the branches, is filled with germs (or rather, we would say, endowed with a capacity of producing them), when the parts, previously existing, receive such injury as to render these new productions necessary to supply the place of the former.

Roots also possess this capacity of producing shoots as well as the branches. If the root of the elm be exposed, with certain precautions, to the air, it puts forth young branches; and many creeping roots, when they come into light and air, produce branches, which, by transplantation, form individual trees. A sprig of willow, when both its ends are thrust into the earth, yields rootlets from both, while the intermediate portion pushes forth leaves into the air; and the leaves of certain vegetables, as those of cotyledon *calycinum*, are capable, in proper circumstances, of producing entire plants. We may therefore say, adds Du Hamel, that there is perhaps no point of the surface either of the branches, the stem, or the root, which does not contain a germ, ready to develope itself when circumstances shall arise wherein this developement may be useful to the parent tree.

Nay, more, continues the same author, there is not perhaps any point on the branches, the stem, or the root, from which rootlets may not spring, when the conditions required for their developement shall

be present. If the root of a species of *campanula* be cut into pieces, and these pieces be put into the earth, each piece will produce both roots and stems. Of these concealed germs, dissection indicates no trace, until they become sensible in the progress of their developement. From whence do they proceed? From the vessels or the cells? Or are they formed by the sap? Do they exist in a form invisible to us before the tree was headed? This, says he, is pure conjecture, although it is true that, if this operation had not been performed, the sap would have continued its course in the parts already formed, and would not have aided in developing the germs of which we speak. But, not to abandon ourselves to imagination, it is sufficient, he adds, to have shown the immense fertility of vegetables, first, by seeds; and, secondly, by invisible germs, of which but a small number of analogous facts are to be found in the animal kingdom. In these remarks, Du Hamel, the Haller of vegetable physiology, evidently leans to the doctrine of pre-existing germs, which at one time so much occupied the attention of naturalists; but of which he ultimately disposes, with that good sense and real candour, which are not less admirable in all his writings than the talent and information which they every where display.

CHAP. III.

Of the Vital Powers, Secretions, Spontaneous Motions, Sleep, Decay, and Death of Plants.

Art. I.—*Of the Vital Powers.*

Such is a brief outline of those vegetable functions which comprehend the evolution, growth, and reproduction of plants. In the description of these functions, we have endeavoured to keep within the limits of observation and experiment; and, in reasoning from the facts derived from these sources, we have adhered strictly to explanations, which apply only to the *physical* constitution of plants. But we are aware, that, to accomplish these physical changes, not only is a particular structure required, but that structure must be endowed with the property or principle that distinguishes living organized beings from dead and inorganic matter. Without embarrassing ourselves with inquiries into the nature and origin of life, we are content, on the present occasion, to seek it only in its effects; to regard it as a power or property not less essential to the constitution of living matter, than gravitation is to that of dead matter; and, rejecting all speculation about its nature, to study only the physical conditions required for the display of its operations, and, as far as we are able, trace the laws by which those operations are regulated. "It is not," says Dr Franklin, "of much importance to us to know the manner in which Nature executes her laws; it is enough, if we know the laws themselves. It is of real use to us to know that china, left in the air unsupported, will fall and break; but how it comes to fall, and why it breaks, are matters of speculation. It is a pleasure, indeed, to know them, but we can preserve our china without it."

Beside the evidences of a living power in plants derived from the ordinary phenomena of growth and reproduction, the function of secretion by which growth is sustained, and various new products formed, deserves more particular notice. Other evidences of this power have been drawn from the various motions exhibited by the roots, leaves, flowers, and fruits of plants; and also from the phenomena of infancy, maturity, and old age, which they exhibit in the successive periods of their existence. To enable them to execute these different functions, and exhibit these phenomena, some physiologists have pushed the analogies between plants and animals to an unwarrantable extent; and, in addition to all the attributes connected with growth and reproduction, have endowed plants not only with irritability but with sensibility, instinct, perception, and volition. In ascribing to them these attributes, more attention seems to have been given to a supposed correspondence in effects, than to a real agreement in the structure and functions of organs. Neither has any very nice distinction been taken between what may be due to physical agents, acting on vegetable organization; and what, from our present inability to explain on *physical* principles, we are too apt at once to attribute to what are called *vital* principles or causes. It is only, however, where physical explanations altogether fail, that it is allowable to resort to the mysterious aid of vital causes: And as the Natural Philosopher, in treating of inanimate matter, assumes gravitation as a fact, and, without investigating its nature, proceeds to describe the laws of its action—so the Physiologist, in studying living bodies, may regard life, and direct his inquiries rather to the laws by which it acts, than to the nature or principle of its action.

Art. II.—*Of Secretion.*

By secretion is understood the separation of a peculiar matter from the general mass of fluids by some particular structure, and which may either retain its primary condition, or pass into a solid state. Though the mass of fluid from which secretions are produced be one and the same, and the secreting organ, as to external conditions, be often in the same circumstances, yet the matters secreted differ greatly from each other, which difference arises, probably, from variety of structure in the secreting organs. Thus, an essential oil is found only in the rind of the orange, a fat oil only in the kernel of the almond, and so with regard to other secretions which exist only in particular parts. Besides the acids, alkalis, earths, and metals, which, though of a mineral nature, are more or less constantly found in plants, chemists enumerate about forty products of vegetation, which possess distinct chemical characters; and of many of these products numerous varieties exist. As none of these substances can be detected in the common sap, they must have been elaborated by the specific organs of vegetables, under a process of secretion. By what peculiarity of structure, or of function, these organs are enabled to produce such remarkable chemical changes in the common sap, is quite unknown; neither do we know how much is to be attributed to the action of the organ itself, or to the reaction of the several ingredients on each other, or to the influence of external agents.

Of these secretions, the most important is the *cam-*

bium, the fluid employed directly in vegetable nutrition and growth. By the changes which the common sap undergoes in the leaves, the "proper juices" of plants are formed. These juices differ greatly from each other both in their sensible and chemical qualities. It is from them that the cambium is directly formed by a process of secretion, and in all plants is said to possess nearly the same characters. It is a mucilaginous fluid, without colour, odour, or taste; while the "proper juices" themselves exhibit all those properties. The "proper juices" also are contained in the vessels, and flow out when they are divided; but the cambium transudes rather than flows, and that only in places where new parts are to be formed. Thus, in the pine, says Mirbel, while the "proper" or resinous juice flows in the large vessels, the cambium transudes beneath the *liber;* and similar observations on the fig show that the cambium is entirely distinct from the proper juice. The cambium, then, we must regard as a *secretion*, separated from the "proper juice" by the vascular structure of the liber or alburnum, when and wheresoever it is required to support nutrition and growth. Hence, in an experiment of Du Hamel, when a piece of the bark of a peach tree was engrafted on the wood of the plum, the new wood, formed beneath the bark, was white like that of the peach, not red like that of the plum. Of the other secretions of plants, which, for reasons already assigned (§ 169), are found chiefly on the *external* parts, as the leaves, flowers, fruits, &c., the number and diversity are very great; they are formed, probably, in each instance, by peculiar and appropriate organs, but in what manner is quite unknown.

Art. III.—*Of the Spontaneous Motions of Plants.*

Although plants, as is well known, possess no locomotive power, yet, in different parts, they often exhibit what are deemed spontaneous movements. In cloudy weather through the day, and always towards evening, many plants, at certain hours, close their leaves and flowers. Bonnet remarked, that the leaves of certain plants approached by their superior surface when the sun shone; but as he declined or set, they fell down, and, even in some instances, approached by their inferior surface. If heat was applied to leaves thus closed, they would open and fold back in a contrary direction: and, on the other hand, if moisture was applied to leaves that had been folded by the sun's heat, they also would open and fold back as from dew. In these examples, the different conditions of heat and moisture seem very much to influence the movements of the leaves. In like manner, the stalks of many fruits change their office under the different conditions, with respect to moisture, that accompany the ripening process: for under the desiccation which then occurs, many of them, says Du Hamel, exercise movements not unlike those of muscular action, and are thereby enabled, in some instances, to scatter their seeds.

We have already described many important effects produced in plants by the direct action of light, and have now to notice the influence it exerts on their movements. If plants be confined in a chamber, where there is but one window, all the younger shoots will forsake their perpendicular direction and make towards the light. In like manner, a young tree, when growing in the midst of older ones, pushes rapidly upwards, till it reaches the height of those that surround it, when it ceases to grow in height, but augments in size: or, if a young plant be made to grow in an opake vessel pierced with holes which admit the light, the shoots it puts forth will be directed towards the holes. The sun-flower, and, according to Bonnet, the mallow, clover, and others, follow the sun more or less distinctly in his course from east to west. This motion in the sun-flower is not produced by a twisting of the stem, but by a real nutation, caused, says Du Hamel, by a shortening of the fibres. The smooth upper surfaces of leaves look naturally to the heavens; the lower surfaces regard the earth. M. Bonnet contrived experiments in which these natural positions of the surfaces should be reversed: and nevertheless, under the influence of the solar rays, they soon resumed their ordinary aspects. In these movements, the petiole is turned about so as to bring the reverted face of the leaf to its natural position; and this operation may be repeated many times on the same leaves, but at length the petiole, at the place of torsion, seems to suffer. In these movements, M. Bonnet ascertained that neither heat, nor humidity, nor air, had much influence; so that the sun, says Du Hamel, in causing these motions, acts more by his light than by his heat.

But there are other movements, proper to certain plants, or to particular parts of them, over which light exerts little or no power. Many observations have been made on the motions of the sensitive plant by Hooke, Du Hamel, and others. The latter author remarks, that the movements of this plant do not depend essentially on light or heat: for if kept in a green-house, it closes its leaves early in the evening, before the sun has withdrawn, and while the temperature is yet high; or if placed in perfect obscurity, it still continues to open in the morning, and close in the evening as before. If, during its expansion in the early part of the day, it be gently touched, its leaves partially close, but soon recover their former state. Mere touch, however, without agitation, does not produce motion: for the leaves may be pressed between the fingers, without causing motion, if no agitation be given. With proper address, it is possible, says Du Hamel, to divide the mid-rib of a leaflet, without exciting motion in the other leaflets, or even in its own folioles; nor does motion follow the puncture of a needle, if all agitation be avoided. The time required for a branch, that has been touched, to resume its former state depends on the vigour of the plant, the hour of the day, the season, &c: and the order in which the parts re-establish themselves likewise varies.

The motions of this plant seem to depend much on peculiarity of structure. From a branch proceed the branchlets that bear the leaves. These leaves are formed of a common petiole, which at its extremity terminates in four conjugate leaflets, each of which has a mid-rib, furnished with a certain number of folioles. In the movements of this plant, the branchlets are so articulated with the branch, that they move on it in the manner of a hinge. The

common petiole of the leaves has a like movement; and lastly, each foliole moves on its proper stalk to apply itself to the opposite foliole. This peculiarity of structure explains why agitation is so necessary to the movements of this plant; and why it bears such great violence without moving, if no agitation be employed to excite motion in its several articulations; so that it is principally in the articulations, says Du Hamel, that the sensibility of this plant resides. He adds, that, when this plant closes, it is not through weakness, but by a sensible contraction, which resists any attempt to replace it in its former state.

In certain flowers also, spontaneous movements take place at the period of fecundation. The stamens of the barberry approach towards the pistil on the slightest irritation, as do those of the sun-flower and other plants. During the night, the petals of many flowers close, and thereby protect the stamens and pistils; but they cease to do so after fecundation is effected. The water-lily is said to bear its flowers on a footstalk under water; and when the flowering season arrives, the stalk rises through the water, till the flowers reach above the surface. The flowers then expand, and the anthers burst and discharge their pollen on the stigma in the usual way. About four o'clock in the afternoon, the expanded flowers close, and the stalk then lies down either upon or under the water. The next day, it rises as before, and continues to do so daily until fecundation is completed, when it sinks beneath the surface, and there remains to ripen its seeds. Other spontaneous movements are exhibited by claspers and tendrils in seeking support from neighbouring bodies, and by roots in the directions they take in search of food.

Unable to assign physical reasons for these and similar phenomena, some naturalists, guided by vague analogies drawn from the animal kingdom, ascribe these movements in vegetables to sensation and perception, by which they not only *feel* their wants, but *perceive* the best mode of gratifying them; and in the performance of the actions necessary to accomplish their objects, they are, according to some, directed by Instinct, and, according to others, by Volition. Such modes of reasoning not only afford no explanation of the phenomena described, but supersede all necessity for it; and are apt, therefore, to beget a conceit of knowledge where ignorance alone prevails. In reference to such attempts at explanation, Du Hamel well observes, that "every peasant has remarked the fact, that the radicle of the seed tends always towards the earth, and that the plume rises in the air. If we ask of them why one part thus strikes into the earth, and the other seeks the air, they give the fact for a reason, by replying that the one part strikes down because it is the root, and the other ascends because it is the stem. And let not us, he adds, smile too complacently at these modes of expression; for we ourselves use them every day when we raise questions about things which are unknown to us. Do we not say that a stone falls because of its gravity? And those who give for a reason that it is attracted by the earth do not satisfy the real philosopher, who never is content with simple terms void of meaning. To me it seems both more simple and more honest to make at once a confession of our ignorance."

Art. IV.—*Of the supposed Sleep of Plants.*

Some writers, deeming plants to possess voluntary power, have from thence inferred that they require sleep. We have no proof, however, that they possess any such power; nor that, in the exercise of their ordinary functions, they experience that fatigue and exhaustion which renders sleep necessary to their restoration. All the spontaneous movements of vegetables previously described, seem to arise from the operation of physical agents, conjoined with those inherent properties which belong to them as living beings. These agents act variously on different plants; and hence some close their leaves and flowers from the abstraction of heat or moisture, and others from the exclusion of light; and this at various periods of the day, as well as through the night. Other plants exhibit spontaneous movements only in the flower, and at the season of fecundation, when suitable conditions of the atmosphere prevail: and though, in some instances, these motions continue for a time after the conditions required for their display may have been withdrawn, yet we must ascribe such motions rather to habit than to any thing that partakes of the nature of volition.

The diminution or suspension of action that occurs, through the night, to plants that inhabit temperate climes, cannot be received as a proof of sleep, induced by exhaustion of the vegetative powers; for even in such climes, vegetation, in favourable seasons, proceeds often by night as well as by day. In climates still more favourable, the same plants which produce fruits only once a-year with us, yield two or more crops; and in Norway and Lapland, where the sun, at certain periods, continues almost constantly above the horizon, the whole period between seed-time and harvest sometimes occupies only about fifty days. In such cases, little or no suspension of the vegetative functions can have taken place; nor have we the smallest reason to believe that the continued exercise of them is followed by fatigue or exhaustion sufficient to require sleep. What, therefore, has commonly been denominated the "sleep of plants," we can regard only as a diminution or suspension of the vegetative functions, arising from the abstraction, more or less complete, of those external agents, whose presence is essential to their full operation and display.

Art. V.—*Of the Decay and Death of Plants.*

But whether the functions of vegetables unceasingly continue, or be occasionally suspended by the abstraction of the conditions necessary to their exercise, all plants submit at length to the same general law, and die, either in whole or in part, when the great purposes of their existence—those, namely, of growth and reproduction—have been accomplished. Some plants speedily arrive at maturity, and, having produced their seeds, die altogether: others flourish for one or two seasons, and then decay and perish; and others again die only in part, after having produced their seeds, and also a new series of buds to carry

on their continued growth and fructification. In the progress of our inquiry, we have seen that, in every stage of vegetation, certain organs fall into decay after having fulfilled their allotted functions. Thus the tunics of the seed perish beneath the soil, after having yielded their nutrient matter to carry on the evolution of the embryo; and those cotyledons, which rise into the air, decay also, when the radicle has taken its proper hold of the soil, and the leaves are sufficiently developed to execute their appropriate functions. So likewise the petals, the stamens, and pistils of the flower, rapidly fade and fall as soon as the important function of fecundation is effected; the fruits next drop when they have reached maturity; and lastly, the leaves, even of perennials, when their allotted functions have ceased, decay and fall like those of annual plants.

To account for this *fall* of the leaves, many hypotheses have been proposed. Some have ascribed it to defective transpiration, and consequent accumulation of juices in the vessels; others to an inequality of growth between the stem and petiole of the leaf, during the progress of vegetation; others to the desiccation of cellular tissue, supposed to exist at the insertion of the petiole with the stem; others to a simple sloughing of worn-out parts; and by others, the fall of the old leaf has been attributed to the growth of the new bud. In all the examples enumerated above, of the decay and fall of cotyledons, flowers, and fruits, the organs ceased to execute their functions, when the purposes of their existence were accomplished; and such we must regard as the general law that determines the death of the leaves. In some instances, the death of parts seems to be hastened by the diversion of nutrient matter from the older organs to the new parts which are subsequently developed, as is exemplified in the decline and fall of the stamens and pistils from the growth of the ovary after fecundation; but, in other instances, as in the death of annual plants, no such acting cause is apparent; and nothing remains to account for the event that occurs, save the character of duration, more or less extended, which was impressed on the plant at the era of its formation.

But from whatever cause the deciduous organs of plants cease to perform their functions, the immediate cause of their fall seems to vary in different vegetables; and to depend often on accidental circumstances of climate, &c. In some instances, the growth of the young bud seems to occasion the fall of the leaf. Thus, though the leaves of the oak die and become dry in autumn, they do not, says Du Hamel, fall till spring, when the buds begin to open, and the new leaves to appear. In other instances, the fall of the leaf seems to be connected with the exercise of the transpiratory function; for plants which transpire largely soonest lose their leaves, and hence evergreens, which transpire little, retain their leaves longest. Even if an evergreen be engrafted on a deciduous tree, it still retains its leaves after those of the stock have fallen. Sudden changes of temperature and humidity in the atmosphere, frequently promote the fall of leaves; thus, in autumn, when rain succeeds to a white frost, the leaves sometimes rapidly fall. So, likewise, it sometimes happens, that the too great heats of summer dry up the leaves; and then also, if warm rains follow, the dried leaves fall and new ones succeed, which continue longer than those of spring. On the other hand, leaves equally fall, though not so speedily, when the winter is mild; and in conservatories, where a regular temperature is kept up, deciduous plants lose their leaves in spring, when the new ones shoot forth. Certain accidents or diseases, however, as lightning, or the eruption of the proper juice from its vessels, or a peculiar disease which separates the bark from the wood, sometimes kill a tree suddenly; and then, says Du Hamel, though the leaves become dry, they adhere strongly to the branches. These facts show, that, while the natural *death* of the leaf is to be sought in the specific nature and constitution of the plant to which it belongs, its *fall* depends sometimes on the growth of new buds; or on variations in the motion of its fluids; or on sudden changes in the temperature and humidity of the atmosphere; and sometimes, probably, the period of the fall is determined by a difference of texture in the fibre of the plant itself.

The duration of the stem or trunk, after the leaves have fallen, is very different in different plants. In many herbs the stem dies at the same time, or shortly after the leaf; but in some trees, the life of the trunk is prolonged through many ages. The *Gentleman's Magazine* for 1762 contains an account of the age of a chesnut tree, then growing at Tamworth in Staffordshire. This tree, it is said, was, at that period, probably the oldest, if not the largest, in England, being 52 feet in circumference. Its period of rising from the nut may be fixed at the year 800, in the reign of King Egbert. From that date to the reign of Stephen is 335 years, at which time it was fixed on as a boundary or landmark, and called, by way of distinction, the *Great Chesnut Tree of Tamworth*. From the first year of Stephen, *anno* 1135, to 1762, is 627 years; so that its entire age, at that period, was 962 years. It bore nuts in 1759, from which young trees were raised. In this tree, therefore, the faculty of producing seeds remained at the age of more than 950 years; but whether this faculty continues through the entire life of such trees is not known. In annuals, we know that life ceases in the whole plant soon after reproduction has been accomplished; but the observations of Mr Knight seem to show that, in certain trees, as those of the apple and pear, the reproductive powers cease before those of vegetation terminate. The death of plants at such various ages, yet occurring at the same age in plants of the same species, suggests the belief that a period, beyond which life cannot extend, was assigned to each species at the era of its creation, and that this character of duration, like the others peculiar to the species, is transmitted through all succeeding generations. (Q.)

WAGES. See TAXATION, page 620.

WAKEFIELD (GILBERT), a commentator and critic of some celebrity, born at Nottingham, 22d February 1756, was the son of the Reverend George Wakefield, Rector of the parish of St Nicolas.

He was observed in his earliest infancy to be of a serious turn of mind, and he made a rapid progress in the first elements of literature. At the age of seven, he was sent to a free school at Nottingham, and remained there two years, chiefly under the tuition of Mr Beardmore, afterwards master of the Charterhouse: he was then sent to a school kept by the Reverend S. Pickthall, at Wilford, an institution which seems to have been only distinguished by the regular imprisonment of the boys for no less than eleven hours a day. After this, when his father obtained the vicarage of Kingston in Surry, with the chapelry of Richmond, he was placed under the care of his curate, who kept a school at Richmond; he was, however, removed in 1769 to a better conducted establishment in the same neighbourhood, kept by the Reverend R. Wooddeson, of whom he speaks in his Memoirs with high approbation.

At sixteen he went to Jesus College, Cambridge, where his classical studies still continued to be the principal object of his attention, although he was so fortunate as to obtain the rank of second wrangler at the termination of his academical studies in 1776. He has, indeed, the candour to observe, that the year was below mediocrity, with regard to the performances of the candidates in general; and that, when he obtained the second classical medal, on the Duke of Newcastle's foundation, he had only one competitor; still, it must not be denied, that to be both second wrangler and second medallist, in any year, implies no ordinary portion of application, as well as some considerable talent. Mr Wakefield was however distinguished, throughout his life, by a singular mixture of opposite habits; and, in the midst of his studies, he confesses, that "he sometimes felt himself almost incapable of reading a single page for months together," and in summer especially, he could only wander about the fields in a state of perfect inactivity. On the other hand, he says, that, "for five years, he rose, almost without exception, by five o'clock, winter and summer, but never breakfasted, drank tea, or *supt* [supped]," or of course dined, "alone, half a dozen times during all that space, enjoying society, from the first, beyond measure."

He became a Fellow of Jesus College in 1776, and he gained, in two successive years, the second Bachelor's prizes given by the Chancellor: in 1778, he was ordained, by the Bishop of Peterborough, though he did not subscribe the Articles without great reluctance. He obtained a curacy first at Stockport in Cheshire, and then at Liverpool. The year after, he married Miss Watson, a niece of the Rector of Stockport, and thus vacated his fellowship: his domestic life appears to have been happy and harmonious, though the only merit of his wife, that he has left upon record, is the singular hereditary qualification, that her great grandfather and great grandmother had lived together as man and wife for seventy five years.

Soon after his marriage, he became classical tutor in the dissenting Academy at Warrington, though he did not professedly unite with any specific community of dissenters as adopting all their opinions; but he soon began openly to attack those of the established church in a multitude of controversial writings, and especially in the notes accompanying his new translations of some parts of the Scriptures; a work for which he had diligently laboured to prepare himself by the study of various dialects of the Oriental languages.

After the dissolution of the Academy of Warrington, he lived at Bramcote in Nottinghamshire, at Richmond, and at Nottingham; partly occupied in the instruction of a few pupils, and partly in pursuing his own studies and illustrations of antiquity. In 1786, and for two or three years after, he suffered greatly from an acute pain in his shoulder, which interfered materially with the prosecution of his theological investigations.

In the year 1790, he accepted the classical professorship at Hackney; here his lectures and instructions were generally approved and admired, but he carried his dissent from the articles of faith of any established society of Christians so much further than any of his colleagues, that he was thought too independent to continue in his situation, and he consequently left the institution in 1791; and for a similar reason he failed of obtaining the charge of two private pupils whom he expected to have been placed with him.

He continued to reside at Hackney, employing himself partly as an author and editor, and partly in the education of his own children. Among his original productions were several polemical and political pamphlets, relating to the war with France, and to the various controversies of the day; of these, the most remarkable for its consequences to himself was his *Reply* to the Bishop of Landaff's *Address*, which occasioned a prosecution to be brought by the Attorney General against his publisher first, and then against himself; and he was sentenced to be confined for two years in Dorchester jail; a punishment which was probably intended to be somewhat severe, but which was most fortunate in its operation on his subsequent comfort, since it was the cause of his obtaining, by the exertions of his friends and his partisans at large, a subscription of about L. 5000; a sum which not only alleviated the rigour of his imprisonment, but also enabled him to leave his family in a state of comparative affluence.

He was principally occupied during his confinement in continuing his literary labours for the press, and in preparing a series of classical lectures, begin-

Wakefield.

ning with the illustration of the second book of Virgil's *Eneid,* the first course of which he delivered in London immediately after his liberation in May 1801. The effect of unusual exertions of body and mind, after so long a cessation of exercise, and in hot summer weather, appears to have predisposed his constitution to a typhous fever, of which he died, after a fortnight's illness, the 9th of September 1801, leaving a widow and six children, four sons and two daughters. His brother, the Rev. Thomas Wakefield of Richmond, also survived him, and died in 1806. The catalogue of his literary offspring is so multitudinous, that it partly tells its own story by its length, and admits of very few particular remarks.

1. *Poemata : quibus accedunt quædam in Horatium Observationes.* 4. Cambr. 1776.

2. *A Plain and Short Account of the Nature of Baptism.* 12. Warr. 1781.

3. *An Essay on Inspiration.* 8. Warr. 1781.

4. *A new Translation of the First Epistle to the Thessalonians.* 8. Warr. 1781.

5. *A new Translation of the Gospel of St Matthew.* 4. Warr. 1782.

6. *Directions for the Student in Theology.* 12. Lond. 1784.

7. *A Sermon Preached at Richmond on the Peace.* 8. Lond. 1784.

8. *An Inquiry concerning the Person of Jesus Christ.* 8. Lond. 1784.

9. *On the Origin of Alphabetical Characters.* Manch. *Mem.* I. 1785. *Life,* II. Attempting to cut the knot of their invention by referring it to inspiration.

10. Several *Letters* signed Nepiodidascalos, in the *Theological Repository.* Lond. 1785.

11. *The Poems of Mr Gray,* with *Notes.* 8. Lond. 1786.

12. *Virgilii Georgica.* 8. Cambr. 1788.

13. *Remarks on Dr Horsley's Ordination Sermon.* 12. Lond. 1788.

14. *Four Marks of Antichrist.* 8. Lond. 1788.

15. *A new Translation of Parts of the New Testament wrongly translated.* 8. Lond. 1789.

16. *An Address to the Inhabitants of Nottingham.* 8. Lond. 1789.

17. *Remarks on the Internal Evidence of the Christian Religion.* 8. Lond. 1789.

18. *Silva Critica.* I. 8. Cambr. 1789. II. 1790. III. 1792. IV. Lond. 1793. V. 1795. Intended for the illustration of the Scriptures from the Greek and Roman writers. The last two parts were printed at the expense of the Rev. R. Tyrrwhitt.

19. *An Address to the Bishop of St David's.* 8. Birm. 1790. On the Liturgy.

20. *Cursory Reflections.* 8. Birm. 1790. On the Corporation and Test Acts.

21. *An Inquiry into the Expediency and Propriety of Public or Social Worship.* 8. Lond. 1791. Ed. 3. 1792.

22. *Memoirs of his Life.* 8. Lond. 1792. 2 Ed. 2 v. 8. 1804. Continued by Mr Rutt and Mr Wainewright.

23. *A Translation of the New Testament.* 3 v. 8. Lond. 1792. 2d ed. 2 v. 8. 1795.

24. *Strictures on Dr Priestley's Letter concerning Public Worship.* 8. Lond. 1792.

Wakefield.

25. *Reply to the Arguments against the Inquiry.* 8. Lond. 1792.

26. *Evidences of Christianity.* 8. Lond. 1793.

27. *The Spirit of Christianity compared with the Spirit of the Times.* 8. Lond. 1794. 2 editions.

28. *An Examination of the Age of Reason.* 8. Lond. 1794. 2 editions.

29. *Remarks on the General Orders of the Duke of York.* 8. Lond. 1794.

30. *Horatii quæ supersunt.* 12. Lond. 1794.

31. *Tragœdiarum Græcarum delectus.* 2 v. 8. Lond. 1794. The *Eumenides, Trachiniæ, Philoctetes, Hercules, Alcestes,* and *Ion.*

32. Pope's *Works, with Remarks and Illustrations.* Vol. I. 8. Warr. 1794.

33. *A Reply to Paine's Second Part of the Age of Reason.* 8. Lond. 1795.

34. *Poetical Translations.* 12. Lond. 1795. Especially from Horace and Juvenal.

35. *Bionis et Moschi quæ supersunt.* 12. Lond. 1795.

36. *Virgilii Opera.* 12. Lond. 1796.

37. *Observations on Pope.* 8. Lond. 1796.

38. *A Reply to the Letter of Edmund Burke, Esq.* 8. Lond. 1796. Twice reprinted.

39. Homer's *Iliad* by Pope, with *Notes.* 11 v. 8. Lond. 1796.

40. *Lucretius de Rerum Natura.* 3 v. 4. and 8. Lond. 1796, 1797. A splendid book, with some collations of manuscripts, and some notes of Bentley. But the collations are said to be inaccurate, and the commentary more prolix than judicious. See Porson in *Br. Critic,* 1801, XVII. p. 452, and Elmsley in the *Classical Journal.* He received, however, many grateful and panegyrical acknowledgments from his German correspondents. The edition is dedicated to Mr Fox, with whom he commenced an acquaintance on the occasion.

41. *In Euripidis Hecubam Diatribe.* Lond. 1794. On Porson's *Hecuba.*

42. *A Letter to Jacob Bryant, Esq. on the War of Troy.* 4. Lond. 1797.

43. *A Letter to William Wilberforce, Esq.* 8. Lond. 1797. Reprinted.

44. *A Reply to some parts of the Bishop of Landaff's Address to the People of Great Britain.* 8. Lond. 1798. Twice reprinted.

45. *A Letter to Sir John Scott, his Majesty's Attorney General, on the subject of a late Trial.* 8. Lond. 1798.

46. *Defence delivered in the Court of King's Bench.* 47. *Address to the Judges in April.* 48. *Address to the Judges in May.* Printed, but not published.

49. *The First Satire of Juvenal Imitated.* 12. 1800. *Life,* Vol. II.

50. *Correspondence with the late Right Hon. C. J. Fox.* 8. Lond. 1813. Chiefly on subjects of Classical Literature.

But few of the characters that have ever employed the pen of a biographer, have exhibited more remarkable contrasts, either in a moral or in a literary

Wakefield. point of view, than that of Gilbert Wakefield: and he has accordingly been depicted, by critics and historians of various sentiments, in colours the most opposite and the most discordant. "Of his particular modes of thinking on religious and political subjects," says Mr Lindsay, "different men will form different opinions: concerning the integrity of his heart, and the consistency of his character, there can be but one opinion amongst those who enjoyed the happiness of his acquaintance." It would, indeed, be difficult to find out a more splendid example of high honour and self denial, and of magnificent liberality, even under actual pecuniary embarrassment, than Mr Wakefield displayed, at a time when he had to support himself, with a wife and six or seven children, on about L. 150 a year, in voluntarily paying the expenses of Mr Cuthell on his prosecution for publishing the *Reply* to the Bishop of Landaff's *Address*, which exceeded the whole yearly amount of his income. "His devotedness to study," says his friend Dr Aikin, "was by no means attended with a reserved or unsocial disposition; for no one could delight more in free conversation, or bear his part in it with a more truly social spirit: and if, in controversial and critical writings, he was apt to indulge in the contemptuous and severe expressions which he found too much sanctioned by polemical use, in disputation by word of mouth he was singularly calm and gentle, patient in hearing, and placid in replying. To conclude the topic of [his] moral character, it was marked by an openness, a simplicity, a good faith, an affectionate ardour, a noble elevation of soul, which made way to the hearts of all who nearly approached him, and rendered him the object of their warmest attachment." But "he wanted time or patience," says Dr Parr very justly, "for that discrimination which would have made his conjectures fewer indeed, but more probable, and his principles more exact: [yet] I shall ever think of him as one of the best scholars produced by my own country in my own age." The compliments of Heyne, and of his pupil Jacobs, are still more elaborate: but it is well known that when Porson was one day asked for a toast, with a sentiment from Shakespear, he gave "Gilbert Wakefield, *What's Hecuba to him, or he to Hecuba?*" and there was quite as much of truth as there was of neatness in the application. A reviewer of his *Life* in the *British Critic*, by no means favourably disposed towards him, readily admits, that "he was strictly and enthusiastically honest, and seems to have acquired even a passion for privations: these feelings, added to his pride of independent thinking, led him, we doubt not," he says, "to abstain from wine; to have relinquished in part, and to be tending entirely to give up the use of animal food, with various other instances of peculiarity. Knowing his own assiduity, and giving himself ample credit for sagacity, he thought that he was equal to the decision of every possible question: and thus he became bigotted to almost every paradox which had once possessed his very eccentric understanding. He was as violent against Greek accents as he was against the Trinity, and anathematized the final N as strongly as Episcopacy. Whatever coincided not with his ideas of rectitude, justice, elegance, or whatever else it might be, was to give way at once, and to be rescinded at his pleasure, on pain of the most violent reprehension to all opponents; whether it were an article of faith, a principle of policy, a doctrine of morality, or a reading in an ancient author, away it must go, *κύνεσσιν οἰωνοῖσί τε πᾶσι*, to the dogs and the vultures. These exterminating sentences were also given with such precipitancy, as not to allow even a minute for consideration. To the paper, to the press, to the [public], all was given at once, frequently to the incurring of the most palpable absurdity. Thus the simple elegance of *O beatĕ Sexti*, in Horace, was proposed, *in an edition of that author*, to be changed to *O bea Tē Sexti*, though the alteration, besides being most bald and tasteless, produced a blunder in quantity so gross, that no boy, even in the middle part of a public school, would have been thought pardonable in committing it. By faults [either] original or habitual, his sincerity became offensive, his honesty haughty and uncharitable, his intrepidity factious, his acuteness delusive, and his memory, assisted by much diligence, a vast weapon which his judgment was totally unable to wield."

It is not impossible that Mr Wakefield might have been more successful in his studies, if he could have found sufficient motives for directing them rather to scientific than to philological pursuits: for he seems to have been fully impressed with the superior dignity of science to that of any department of philology. "Compared with the noble theories of *mathematical* philosophy," he says, "our *classical* lucubrations are as the glimmering of a taper to the meridian splendour of an equatorial sun." He would, however, scarcely have had perseverance enough to distinguish himself in that solitary labour which is required for the minute investigation of natural phenomena: and it is seldom that any collateral encouragement is held out, in this country, for the continued cultivation of abstract science; while the classical scholar, though he is supposed to be principally occupied with nouns, and verbs, and particles, is, in fact, unconsciously, and, therefore, most effectually, learning the arts of poetry, and rhetoric, and logic, which have furnished, in all ages, the spur and the reins for urging on and directing the mighty bulk of the body politic, in church and in state, at the will of its leaders. The young man, on the other hand, who commences the pursuit of science with ardour, obtains, if he is most successful, and untormented by unnecessary scruples, a quiet fellowship, a comfortable apartment, and an excellent plain dinner for the remainder of his life: and if he fails of these, he may chance to be made an exciseman; or, in the improved arrangements of the present auspicious days, a computer or an assistant astronomer: but with respect to any influence that his pursuits might be supposed to have on the elevation of his rank in life, or in the independent provision for a family, he must lay no such flattering unctions to his soul, but must at all times place his pride and his happiness in the reflection that AT MIHI PLAUDO IPSE DOMI, which is, in truth, the best sublunary support of the wise and the good in every circumstance of human life. (A. L.)

New South Wales.

WALES (New South). In the *Encyclopædia*, under the head Holland, New, is given an account of this colony, including a history of its first settlement by a party of convicts conducted there by Governor Philip; a description of the country, and of the natives, and such few slight notices on its internal geography, and animal and vegetable productions, as the narrow limits which then bounded the excursions of the settlers had enabled them to make. In this *Supplement*, under the Article Australasia, the accounts of the settlement are brought down to the year 1814, and copious details given of the results of several expeditions undertaken for the purpose of internal discovery. Considerable discussions having been excited in Parliament, and carried on in the diurnal and other periodical publications, respecting the government of the distant settlements in the southern hemisphere, it was resolved by the Government to send a Commissioner with powers to examine every part of the administration; to report on the condition of the inhabitants in general, on their pursuits, their habits, their property, and their conduct; and to suggest, for the consideration of his Majesty's Ministers, such laws and regulations as might tend to make those settlements less burdensome to Great Britain, and more conducive to the improvement of those persons whose violations of law had created a necessity for their removal from Europe.

From the *Reports* of Commissioner Bigge, whose labours were closed in 1821, and from other papers laid before Parliament, the following accounts of the present state of New South Wales are chiefly extracted, and presented to our readers in a condensed form.

Present state of the Population.

The increase of inhabitants by births, owing to the great disproportion between the males and females, has been very small since the commencement of the settlement, and must continue to be so till the sexes approach nearer to an equality than they do at present. The whole number of convicts exported to New South Wales and to Van Dieman's Land, from the year 1787 to 1820, was 22,217 males, and 3661 females; and the present population of all the settlements in the latter year amounted only to 29,407 persons. The inhabitants of New South Wales, amounting to 23,939, are classed in the following manner, viz. 1307 are persons who came to the colony as free settlers; 1409 are persons born in the settlement; 3255 were become free by the expiry of the terms for which they had been sentenced; 159 had received absolute pardons; 962 had received conditional pardons; 1422 were convicts, but with tickets of leave, which enabled them to work on their own account; 220 were serving on board colonial vessels; 9451 were convicts in a state of servitude; and the remainder, 5668, consisted of children of both sexes. The whole number of females, of all classes and ages, in 1820, were 6310, viz. 3707 women, and 2603 female children. It appears that in thirty-three years, from 1787 to 1820, during which the whole numbers transported have been 25,878 persons, the number of the convicts who have died, who have lawfully returned to Great Britain, or who have made their escape, amounts together to 7080. The greater part of the inhabitants reside either in the town of Sidney (the capital), or in its immediate vicinity. The returns from that place make the inhabitants to be 12,079, of whom 4457 are convicts.

Moral Condition.

Whilst this colony has been increasing in numbers, there is reason to hope it has been instrumental in somewhat improving the moral character of the persons transported to it, or, at least, that their progeny is placed in circumstances less exposed to temptation than it would have been under the tuition of such parents in Europe. There has been a gradual, but general improvement in the moral condition of the society, by the children of convicts arriving at maturity; thus forming, with the free settlers, a nearer proportion to the convicts than was the case at the more early periods of the settlement. The remitted convicts, and those whose time has expired, seem, in some instances, to become useful members of society. Mr Bigge relates, that out of 4376 remitted convicts, including those whose time has expired, 369 may be considered as respectable in conduct and character.

Adjustment of Property among the Classes.

The proportion of landed property acquired by those classes of inhabitants, may be considered as evidence of some improvement in their condition and character. The whole quantity of land granted was, in 1820, 389,288 acres. Of this portion, 20,317 belonged to remitted convicts, and 54,693 to convicts whose time has expired. Thus those classes seem to have a fair proportion of the landed property of the settlement; and we think it may be inferred from the Commissioner's *Reports*, that they possess a large share of the moveable property likewise, as they seem to be the principal persons who own vessels and carry on distant trade. Mr Bigge remarks, that "though the free settlers have not, as a body, been the most successful improvers, either of their own condition or that of the colony, yet the best cultivated estates, and the greatest quantity of cattle, belong to them, though they have not lately engaged in mercantile operations." The large grants that have been recently made have rendered the quantity of land, held by classes of individuals, a less accurate criterion of property than it was before those grants were made. In the year 1810, the land cleared was to the land granted as $1\frac{1}{2}$ to 4; but in the year 1820, when the land granted was 389,000 acres, the portions returned as cleared were 54,898 acres, or as $1\frac{1}{10}$ to 7. Of the cleared land, in 1820, 16,706 acres were cultivated to yield wheat, 11,270 maize, 1230 barley, 379 rye and oats, 213 pease and beans, 504 potatoes, and 1094 in orchards and garden ground.

Agriculture.

The future progress of this colony must depend mainly on the productions raised from the soil, and hence the condition of its agriculture, including the breeding of cattle, becomes a most interesting subject. The first land settled near Sydney, though then moderately fertile, has been exhausted by overcropping, so that a considerable expenditure in manure, or in labour for fallowing, or in both, is indispensable to renew its productive powers. It has hence become necessary to pay attention to the production and proper application of manure, as well as to the cultivation of artificial food for the cattle.

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New South Wales.

Lucerne, sanfoin, and burnet, as well as rye-grass and meadow fescue, have been introduced and gradually assimulated to the climate. It has been remarked of the grass seeds imported from Europe, that their first and second flowering is in conformity with the season in Europe, but that the next time they flower according to the season of New South Wales. The cost of reclaiming an acre of forest land, of converting it into tillage, and of sowing it with wheat, is calculated to amount to L. 6, 10s. The cost of the same operation to fit it for maize would be L. 5, 8s. 6d. Mr Cox, the surveyor, has estimated, that on a farm of 50 acres, when the government supplied subsistence for six months, the expence would exceed the produce L.5, 19s. the first year; that in the second year the produce would exceed the expenditure L.49, 10s., and in the third year L.36, 10s.; after which, recourse must be had to the renovating power of manure. Maize and wheat are grown on the same land in one year; the former when hoed well, and twice hilled up, being found a good preparation for the latter. Wheat is sowed in March or April, and harvested in November. Maize is sowed in November and gathered in April. The produce of wheat on the Hawksbury settlement, from 1804 to 1814, was from 21 to 25 bushels to the acre, and since the last of those periods from 15 to 20 bushels. The land on the rising ground is inferior to that on the borders of the river, but the wheat grown on it, though yielding less in quantity, is of a superior quality. Mr Oxley, the Surveyor-General, thinks the average produce of wheat on the colony does not exceed 10 bushels to the acre; whilst, on land of similar quality, the produce of maize is from 30 to 60 bushels. The price of wheat has been from 11s. to 12s. 6d.; of maize from 3s. to 7s. *per* bushel.

Besides the grains, attempts have been directed to several articles whose cultivation appears suitable to the climate. Flax has been grown with success, but has not been extended from the very limited demand for it in the settlement. Tobacco has been well produced, but from want of sufficient practice in curing the leaves, the tobacco of Brazil has been so generally preferred, as to leave but little inducement to grow it in the colony; though of late, some improvements in drying offer a prospect of more success. Vines have not yet been prosperous, owing to blights which probably have arisen from improper exposure to prevailing winds. As this is an object of great importance, Mr J. Macarthur has paid much attention to rectify any errors, and hopes are entertained of more favourable results in future, than have hitherto been produced. The same gentleman, one of the earliest settlers, with his characteristic spirit, has been at pains to introduce the olive, and as far as can be judged from the trees, which are yet but in their infancy, with the greatest earnest of success. All the finer fruits of Europe are most profusely brought forth, and in some gardens, the choicer kinds of the tropics are successfully cultivated.

Cattle and Wool.

The breeding of cattle must, however, be the most sure road to the prosperity of the colony for some years to come. The numbers of horned cattle have quintupled between the years 1810 and 1820. In the latter year they amounted to 54,103; besides those tame cattle, a race have grown up wild in the woods, derived from some stock which early strayed from the settlement, and which were supposed to have perished, till their offspring were discovered in large herds in the interior. The sheep have been tripled in ten years. In 1820, they amounted to 99,487. Mr Macarthur has a flock of 6800, of which about 300 are pure Merinos, and yield wool of excellent fineness. As the duty on wool from New South Wales has been reduced to 3d. *per* lib. in Great Britain, eager hopes are entertained of success, which will naturally tend to increase the numbers, and to improve the quality of the wool. The average weight of the fleeces of the New South Wales Merinos is about 2 lb. 7 oz. Some few bales of that wool have been sold in England at 5s. 6d. *per* lb., and one at 10s. 4d.; but the far greater part have hitherto sold at about 2s. The importation into Great Britain has been, in 1819, 71,299 lbs.; 1820, 112,616 lbs.; 1821, 175,433 lbs. The increase of horses has been in nearly the same ratio as the sheep. In 1810, they were 1114, and in 1820, 3639. They are generally of the European breed, with a mixture of the Arabian brought from India. Pigs and poultry have increased in nearly the same proportion as other stock. The mineral productions of this settlement are yet but slightly ascertained. Iron has been found about eight miles from Port-Dalrymple, which is said to be equal in quality to that of Sweden. The mines have not yet been worked. There is abundance of coal at Hunter's River, about 50 miles north of Port-Jackson. The vein is three feet thick, was worked by a passage from the river, but is now by a shaft 112 feet deep, and the labour of twenty-seven men can extract twenty tons *per* day. In this labour, the criminals from Sydney are destined to be employed. Lime, for building, has hitherto been burnt from oyster-shells, as no limestone has been discovered near the settled ports. Common salt has been extracted from sea-water, but from the bitter not being accurately separated, the culinary salt of England, notwithstanding its price, is generally preferred.

Manufactures.

The circumstances of the colony are not favourable to manufactories; but some hats, blankets, woollen stockings, and coarse cloths, have been made from the native wool. Pottery wares, of different kinds, have also been made, but they have not yet acquired the art of glazing them. The most advantageous operation of manufacture is tanning; but, from want of sufficient practical knowledge, it has been hitherto badly performed. The bark of the mimosa, a tree that abounds in the interior, is found to contain the requisite properties for tanning hides. With a little more experience, and with some regulations to prevent damage to the hides on flaying them, the colony might supply itself with leather from the cattle bred and slaughtered at home.

Commerce.

The foreign trade of the colony consists of the importations of sugar, spirits, soap, and cotton goods, from Bengal; of tea, sugar-candy, silks, and some clothing, made of English cloth, from China; of iron and hardware, cottons, millinery, wines, porter, cheese, and salted provisions, from England; and of sugar, tobacco, and spirits, from Brazil. The exportations

have hitherto been but trifling. Wool has been already noticed: seal skins and fish oil might have formed returns but for their being charged with higher duty in England, if taken by a colonial than by a British vessel. Exportations to China have been made of sandal-wood, and pearl shells, previously collected at the Islands. Some attempts have been made to export flour to the Cape of Good Hope, and horses to Batavia; some coals have also been shipped for Bengal and for Batavia. The shipping of the colony consists of twenty-seven vessels, from 15 to 184 tons burden. This branch of industry is much retarded in its growth by the restrictions which are found necessary to prevent the escape of convicts by sea.

The external trade has been assisted by the establishment of a bank; but the institution has been injured by having suffered its cashier to defraud it of nearly L. 10,000, being half the capital. The principal circulating medium is the bills of the Government, or receipts for stores received by the Commissary, which amount to about L. 40,000. The smaller operations are performed by means of the notes of the bank, which are issued for 2s. 6d., 5s., 10s., 20s., and five pounds. The legal interest of money in the colony was 8, and is now raised to 10 *per cent.*

By the accounts of the treasurer for seven years, ending September 1821, it appears that the taxes collected in that period amounted to L. 174,310, 10s. and the expenditure to L. 163,790, 8s. The income is derived chiefly from port dues, import duties, licences, and tolls. The chief expenditure has been on the establishments for male and female orphans, and for public schools—for public buildings and works—for salaries to officers—and for public and judicial charges.

In all the grants, reservations of land have been made for the support of the clergy, and for the maintenance of schools. The clergy are under the inspection of one of their number, denominated senior chaplain. Some Roman Catholic chapels are building, and one for the Wesleyan Methodists. The public services of religion are reported to be attentively observed. The administration of justice is executed in a court established by special act of Parliament, in which the Chief is an English Barrister; and recently an Attorney-General has been appointed, who is to be the general prosecutor of all offences.

See Wentworth's *New South Wales; Parliamentary Papers* ordered, by the House, to be printed at the following dates—19th June 1822, 19th April 1821, 13th March 1823, 9th March 1821. (W. W.)

WAR.

The present state of military science presents an inquiry of very considerable extent. To take a luminous view of every branch, would require a compass of theoretical knowledge and practical experience, possessed by very few in any service. Even to attempt a satisfactory essay on any one of the principal branches would be a task of considerable difficulty; if recent authors, of known ability and experience, had not discussed many of the most important questions, and demonstrated the mutual dependence between theory and practice, in all their essential bearings.

Objects of this Article.

In the body of the work, the science is considered under the articles FORTIFICATION, GUNNERY, and WAR. The two former take a sufficient view of their respective subjects; but the latter, including likewise naval war, is contracted to the mechanism of columns of movement and formation in armies; the operations of detachments; and a short account of strategy, position, and field service. But, as no particular notice is taken of the great principles of war, the knowledge of which is of primary importance to the soldier and the politician, and indeed to the general observer, as the only safe guides in the judgment of operations; and as the improvements in this essential branch constitute the most valuable feature in the late eventful wars, we shall endeavour to give as complete a view of its principal combinations as our limits will allow; and by referring to the most signal events in modern times, afford them that illustration, which the reader, if not previously acquainted with the details of the subject, will immediately obtain by referring to any authentic author, in which they are more circumstantially described: reserving for the conclusion, a few observations on minor subjects, of present or future applicability, and a list of the authorities consulted, or whose works are of acknowledged utility in the study of the theory, or in judging the practice of war in military history.

Theory of War.

Jomini has demonstrated that the art of war reposes upon one governing principle, or what may be termed the *Fundamental Maxim;* by the application of which all the combinations are good, and without which they are all faulty. This maxim consists in

Effecting, with the greatest mass of forces, a combined operation upon the decisive point.

To illustrate the subject, it may be observed, that the decisive point in war, or what has been termed the primitive objective point, is obviously that in which resides the principle of strength in an enemy; and it follows, that to be able to destroy it in the shortest and most effectual manner, must be the fundamental principle adopted by his antagonist. The mode of effecting this purpose is, however, the difficult part of the question, because of the infinite variety of circumstances to which it is subjected. But the theory of war may nevertheless be divided into three primitive combinations; because the practice is composed of as many branches, each of which de-

pend upon particular principles: therefore, a great operation, to be perfect, ought to combine the three primitive combinations; because, then, they produce the complete application of the fundamental maxim.

The first of these relates to what is commonly termed forming the plan of a campaign, and consists, either in an offensive or defensive view, in *the art of embracing the lines of operations in the most advantageous manner.*

The second is *the art of moving the mass of forces, in the most rapid manner possible, upon the objective point of the primitive or accidental line of operations.* This is the method of execution, or strategy.

The third is *the art of combining the simultaneous application of the mass of forces on the most important point of a field of battle.* This branch is usually designated by the term Tactics.*

I.—*Plan of Campaign.*

A plan of a campaign depends upon six essential considerations: 1st, The political situation of both parties; 2d, The situation of the moment; 3d, The relative force and military means; 4th, The location and distribution of the armies; 5th, The natural line of operations; 6th, The most advantageous line of operations. In forming the plan, it is not necessary to have regard solely to the exact balance of the relative means of war between the parties, but to view them only as they are important. Territorial and manœuvring lines of operations are the principal object; and though they are subject to many accessory considerations, the rules of the art must nevertheless form their basis. Originality and great boldness are not incompatible with their application: such, for instance, as the plan which Napoleon, in 1800, executed in Italy. No enterprise could be more daring, none more rich in great and decisive combinations, or more prudent and cautious; since, while it menaced the enemy with ruin, no greater misfortune could occur, in case of check, than the sacrifice of the extreme rear-guard.

Before we proceed, it may be useful to fix, by definitions, several terms, upon the comprehension of which the most important militaryreasoning depends.

By *a base or basis of operations* is meant a frontier, the course of a river, a coast, a range of mountains or fortresses, or any topographical or political extent of country, upon the imaginary line of which the corps of an army assemble, offensively,—to take their departure from thence into the enemy's country, and towards which, in case of failure, it is intended to retreat; defensively,—to counteract all the measures which an invading force may pursue.

Lines of Operations are divided into territorial and manœuvring lines. By *Territorial Lines* are understood those which nature or art has traced for the defence or invasion of states. Frontiers covered by fortresses, or defended by nature, with chains of mountains, great rivers, or other obstacles, form their constituents. *Manœuvring Lines* are the dispositions of the general to traverse them offensively, or cover them defensively. Both these lines of operations are intimately connected. In offensive war, the line is an imaginary perpendicular upon the base, along which an army operates against the enemy; in defensive war, it is often the same, but still oftener parallel to the territorial line. *A Line of Communication* is either the same as that of operations, or any other by which the army receives its supplies, and communicates with the base.

Some examples will render the definitions more evident. France and Austria have three great lines of operations against each other—by Italy on one side; Switzerland and Tyrol in the centre; and by Germany on the other. In these the Po, the Meyn, the Danube, or a principal road, constitute the *materiel* of lines; which are amenable to only a few rules prescribed by their nature. Between Prussia and Austria again are three lines—through Moravia, Lusatia, and Saxony. Lines of operations are divisible into collateral or separate points. Frederick entered Bohemia by his central line, upon four points. The French invaded Germany in 1796 and 1799 upon two subdivided lines. Napoleon always operated upon one principal line, as did the Duke of Wellington in Spain.

Thus far no great variety of combinations seem to perplex the view; but in the selection of the particular line, the problem becomes difficult; because a great multiplicity of circumstances, many of them, not purely military, interpose. The political situation of the belligerents; their relative resources; character and situation of the fortresses; accidental strength of their forces; distance by sea; course of a considerable river; direction of a chain of mountains; nature of the country; political state of either party; jealousy of a neutral, or apprehensions of an ally; all in their turn claim consideration. In general, however, the initial application of military masses should be, when the belligerents are neighbours, upon some part of the frontier, which projects into the hostile state; such as Bohemia with regard to Prussia, or *vice versa,* Silesia with regard to Austria. But it is a maxim that lines of operations have their key as well as fields of battle: in the former, the great strategical points are decisive; as in the latter, the points which command the weak part of a position constitute the key. Where there exists a vast superiority of force on one side, the key, or great strategical point, may be sought at a considerable depth in the line of operations; but where the masses are nearly balanced, it is necessarily reduced to a relative proportion with the breadth of the base. Thus, for instance, the destruction of a French army on the frontier of the Netherlands, would not immediately produce the consequence of the victors marching to the capital, unless they had sufficient

* For the sake of perspicuity, when this term is applied to the instruction of troops, it should be distinguished by the qualifying adjective, *Elementary Tactics.* Thus also the phrases, science and art of war, are used as synonimous, while we should understand by the science of war, the knowledge of the theory of all its elements; and by the art of war, the skilful application of that knowledge.

War. superiority to mask the principal fortresses which cover her line of defence in that quarter, or some other accidental circumstance rendered such a measure practicable. As farther proofs of the relative proportion between the depth and base of a line of operations, that of Napoleon in Russia failed on both its pivots, before the summit was defeated; and those in Spain, although they were supported by intermediate fortresses, immediately contracted, when the battle of Salamanca produced consequences which endangered the western communication with the base.

Although it is absolutely necessary to move with a mass of force near the enemy, it is more advantageous to march in separate corps while still at a distance from him, if he has not a concentrated mass ready to act, and there be several roads leading concentrically towards the point intended to be occupied. It is evident, that five corps, of twenty thousand men each, will move forward more rapidly towards any point, than a hundred thousand men, marching on the same road, who can only advance with the tardiness inherent in large bodies, and besides are encumbered with the immense train of their subsistence. Celerity of movement, multiplying the force of an army by enabling the mass to be carried alternately upon every point of the line, is an advantage of invaluable consequence; but this is not the only reason for recommending this method. There are two others, viz. the increased facility of subsistence, and the uncertainty into which it throws the enemy.

An army of 20,000 men can find subsistence, in central Europe, on every part of their march, by merely causing the country, within some leagues, to contribute to their wants; and if they convey with them biscuit for eight or ten days, that is, during the first period while corps are in position, or manœuvring in a contracted area with other columns, they will be enabled to subsist till the magazines are formed. Thus, military operations are, in a great degree, emancipated from the necessity of pre-arranged magazines, and the regular encumbrance of field ovens.

The army which commences offensive operations takes the lead in all the movements, and those of the enemy are necessarily subordinate to them. If, therefore, it occupies with a corps, each of the great avenues leading to the enemy, he will be in a state of uncertainty along his whole line of defence or operations, and remain in suspense as to the point upon which he ought to collect his masses to oppose them. Upon these facts, the following series of maxims are founded:

1. When an army undertakes an invasion, or acts offensively, it takes the lead (or, as the French term it, *l'initiative*) in the movements.

2. This advantage precludes the necessity of marching in mass, until near the point where the enemy is to be found and attacked; until then, it is preferable to move in several strong corps, in proportion to the collective strength of the army, and to direct them upon the communications which lead concentrically to the point.

3. The general direction can only be upon the centre, one of the extremities, or the rear of the hostile line. An extremity will usually be found most eligible, because, from that point, the rear is easily attained; the centre, only in the case where the enemy's line is scattered, and his corps separated by great intervals. War.

4. In this case, the greater number of the corps should advance upon one of the isolated parts, and endeavour to surround it, while the remainder should occupy a central point to keep the rest of the hostile army in check.

5. When the principal mass of these corps is directed into the rear of an enemy, by passing one of the extremities of his line, one corps should remain upon that extremity, in order to keep open the communication with the line of operations, while the opponent is cut off from his. This corps serves likewise to attack him in flank, and to prevent him from withdrawing out of a faulty position by a secret movement.

6. These operations are most advantageous when the enemy is at a great distance from his own base. The principle may, however, be applied to positions less distant (two or three marches); provided the different corps have no greater distance to traverse to the point of reunion, than that which separates them from those of their own advanced posts who face the enemy. But this rule should not be understood as applying to isolated divisions upon an extended front of ninety or a hundred miles, unable to unite on a day of action, and whose movements cannot be simultaneous upon the decisive point. The difference is easily perceived between such operations and those of several corps concentrated in a position, the depth of which equals the extent of front, and whose simultaneous co-operation is certain before the enemy can make an attempt upon their line.

7. By means of this system, the army occupying a greater space marches more rapidly, and is enabled to subsist on the roads. Cattle and biscuit alone will be required to follow each corps, in sufficient quantity to subsist it when in the vicinity of the enemy, where the other corps having likewise arrived, they are obliged to live within a smaller periphery. The stock of provision will be sufficient, if equal to the time required for collecting another.

8. Magazines are then formed in the rear as the army advances. They are collected by means of regular requisitions made on the neighbouring provinces, and enforced by a few troops; contracts are entered into with the local administrations, and precautionary convoys follow from the frontiers. Cattle, rice, and biscuit, are the most useful provisions; the easiest to be transported.

In this view of the theory of initial operations, such as Jomini, and other authorities, consider them, no great regard is paid to the waste of human life, by the frequent want or irregularity of the issue of provisions, or notice taken of the indiscipline which naturally arises when famine drives the soldier to marauding. A relentless conscription system may, indeed, supply recruits; but they are a very inadequate instrument when compared to formed soldiers.

It remains to examine the art of forming a plan of campaign or operations in reference to insular

expeditions. In the application of masses on the base line of operations by sea, or by an insular force, much difficulty occurs; especially if that base is to be obtained by force on an hostile coast; because the line of communication from the port whence an expeditionary army proceeds to the point where debarkation takes place is lengthened, uncertain, and broken. The point of debarkation becomes a secondary base; and unless a friendly fortress, or a naturally advantageous point, left unguarded by the enemy, can be occupied, the difficulties are nearly insurmountable. It is again difficult to despatch a large force in one fleet; it is dangerous to keep it together, and dangerous to allow great intervals; the elements affect the time, connection, and order of the convoy; an independent and separate service (the navy) influences the primary organization and execution; debarkation absorbs much invaluable time, particularly that of the artillery, horses, and stores. From these causes, a practice has arisen of fitting out expeditions not sufficiently formidable, with a view of ascertaining the practicability of an object, but which, by that very system, is often rendered impossible; for the first landing having been effected, the enemy's attention is no longer divided; he assembles his means of defence, while the second convoy is expected, and the delay becomes decisive of the event. Yet if, in any military operation, the effect of masses simultaneously employed be of consequence, it is in those which commence on the sea shore; for the troops have not only to debark and act offensively, but also to construct their means of security and retreat, in case of failure. If we examine the primary operations of this class from the wars of King William to the present period, we shall find that, with the exception of such as were favoured by chance or particular circumstances, the success or failure was dependent upon one or more of the following maxims, especially as applied to continental expeditions:

1. When an army is directed to make a descent upon an enemy's coast, with the object of penetrating into the country, a point of debarkation should be selected, where the enemy possesses no local means to arrest the progress, such as a fortified city or a defensible peninsula. If, however, circumstances compel the descent near or upon such a spot, immediate measures should be taken to mask or capture it, and secure the success of ulterior operations.

2. If the expedition is intended to be confined solely to the coast, the point of debarkation should possess the indispensable qualifications of facility of communication with the fleet; security of retreat; and reimbarkation. A point possessed of these advantages is a fit spot for a temporary base of operations.

3. An expedition intended to operate ulteriorly, should be *ab initio* superior to the probable immediate force of the enemy, so that the success of the landing and march into the country be not problematical.

4. No combinations of invasion should be made depending on the co-operation of corps expected from distant or opposite quarters. It is important to have them collected, as much as possible, on or near one point of embarkation, to proceed from thence in mass to execute the enterprise.

5. In the plan of an expedition, no combinations should be admitted which include two or more lines of operations from separate bases. Armies transported by sea are, from that circumstance, not numerous; division renders them still weaker, and if on one point a misfortune occurs, the other must reimbark.

6. In colonial and insular expeditions, it is only necessary to combine the means in proportion to the strength of the object, and with attention to the season and climate. But on all occasions where the reduction of a fortress is in contemplation, the engineer department should possess an adequate *materiel* as well as the artillery.

All these maxims are in unison with the leading principles of the art of war, or constitute mere modifications to adapt them to maritime affairs. As examples of the importance of the first rule may be quoted, the landing of the Emigrants at Quiberon: being confined to a narrow peninsula, they were immediately blocked in by the enemy. The Helder expedition, though victorious in two battles, could not penetrate beyond the neck of the Haerlemmer Meer, which makes a peninsula of North Holland. At Aboukir, again, a peninsula, similar results would have ensued, but for the circumstance, that a communication could be opened on the side of Rosetta, which rendered the position central against the two exterior lines of the enemy; namely, those of Cairo and Alexandria; and enabled the British to carry their mass alternately upon each, and ultimately with inferior numbers to reconquer that province.

In the second maxim, the causes are pointed out which allowed the expedition to Cherbourg, in 1758, to reimbark in safety, although no regular precautions insured the measure; and those which produced the disaster at St Cast under General Bligh, notwithstanding every precaution. The Ostend expedition had the same defects, though, perhaps, on this occasion the object was considered of sufficient magnitude to allow a disregard of the consequences.

Inattention to the third, had a preponderating influence at the Helder. The first division having landed, was obliged to wait behind the intrenchments of the Zyp for the arrival of the main body. Meantime the enemy, now certain of the point in danger, collected his means, and arranged the plan of defence. After three battles, he was only thrown back upon stronger ground, in a position where he could neither be turned nor attacked in front with probability of success. In Egypt, the expeditionary force was likewise inferior to the enemy, and if the hostile commander had sacrificed the establishments and *Institut* at Cairo, to collect his forces on one line, he could have resisted the invasion with success. The Walcheren expedition, considered in its primary combinations and preparatory measures, was a model; as also that of the French for the invasion of Egypt. Both were wrong in the choice of the point of debarkation; but the results were different, and, from an unconquerable propensity in man, by the results they have been judged.

The expedition to the Helder again furnishes the

proofs of the fourth maxim. Had the two British and the Russian divisions arrived in time to act in mass, within a few hours after the first landing, the enemy could not have matured an effectual plan of defence. But the combinations required easterly winds for the Russians and westerly for the British reinforcements, and both were, nevertheless, to arrive, if possible, simultaneously on the same spot. The Egyptian expedition was to be sustained by a corps from India and the Cape, by the Red Sea, which could scarcely, by any chance, arrive in proper time. At Copenhagen, indeed, the two divisions from Rugen (an island in the Baltic, where a British corps lay in transports) and from England did arrive without accident; but the successive divisions sent to the river Plate, to be successively defeated, are a farther corroboration.

The fifth maxim is sufficiently obvious. Sir John Moore's division was off the coast of Portugal when the battle of Vimiera was fought; had it sailed conjointly with Sir Arthur Wellesley's, the result of that battle would have brought the British into Lisbon *without* a convention. If the division engaged had been defeated, a corps on board of ships could not have rendered the least assistance. In the next campaign, Sir John operated on several lines from Portugal, and Sir David Baird from a different base (Corunna), with the view of uniting at the distance of more than 200 miles on a point in possession of a formidable enemy. Such combinations produced their natural consequences, the hard pressed retreat of the army to Corunna ensued; and, as if another proof were wanting, no sooner were the troops compelled to fight an action, than another division appeared to witness the conflict from the ships, and return to England.

To the deficiency of a proper establishment of sappers and miners, with the *materiel* required to enable the engineers to act with effect, many delays and failures may be ascribed. It has necessitated the severe system of bombardment, and repeatedly rendered the British arms odious, without thereby insuring success. Carcasses and rockets ruin the defenceless inhabitants, but have no decisive influence upon the defence of a regular fortress.

If we examine the wars in America by the rules of art, we find Lord Amherst operating by the line of Lake Champlain upon Montreal, and Wolfe by the St Laurence upon Quebec, both successful, and yet two years without connection. Next appear isolated expeditions traversing a vast continent, deficient in numbers, and therefore always inferior to the local militias on the spot, terminating their career in defeat or capture; or else dispersed along the coast, occupied in landings for trivial purposes, and when reimbarked, leaving the enemy to boast of successful resistance. In the Canadas we behold the key of defensive operations left without a fortress; true, indeed, that a fortress does not defend a state—that an army must be looked to for that purpose; but an army is a frail instrument, and if armies defend nations, fortresses defend armies.

Reflecting on the miscarriages produced by dispersing the forces, it appears, that in British military combinations it should be a maxim, *never to act offensively on more than one point at a time.* This rule, a fundamental principle of the Roman policy in her best days, should have been acted upon in the wars of the Spanish succession, when that question ought to have been decided in the Netherlands. The consequence of pursuing a multiplicity of offensive combinations at the same time, was never better exemplified than in the failures of the simultaneous expeditions to Buenos Ayres, Constantinople, Alexandria, and Rugen. It follows that small expeditions, hovering along hostile coasts, produce no beneficial effects. The local garrisons and militia of the country are generally superior, and a momentary debarkation produces in the mind of the enemy not only national union, but also the ideas of victory. The debarkations at St Malo and St Cast; that under Sir James Pulteney at Corunna; most of those in America, were fraught with risks, not counterbalanced by any prospects of real advantage. Those on the east of Spain were of a different character; they had a political object of importance, and served as a diversion which fixed a whole hostile army in that quarter.

It is a general rule, liable, indeed, to occasional exceptions, *that the operations of the land forces should be confined to fixed important points, where the object is not only to land, but to conquer and maintain themselves.* There is no instance in the history of the nation where a British mass of forces met with disaster, when that mass acted by itself, or with sufficient preponderance among its allies. From the nature of the sea line of operations, expeditions, like other military enterprises, must be liable to miscarriage; but a right use of the forces will at least increase the chances of success. In the selection of the points, much must be left to the circumstances of the case, but their importance should always be in relation to the risk, expence, and time.

As these observations apply to great operations only, it is unnecessary to advert to flying corps, or such expeditions as are merely intended to alarm a coast or distract an enemy; because these, in most cases of problematical utility, should be very sparingly resorted to; and, at all events, never consist of more than a few frigates, with troops on board. The geographical extent and insular position of Great Britain afford equal facilities for defence and attack. Defence, however, when passive, is allowed to be the very worst that can be adopted in the military policy of a state; but when the national superiority at sea is considered, it becomes evident that British operations ought to be offensive. With a great number of garrisons stationed in every quarter of the world, the land forces form no where a considerable body; those in England being scarcely adequate to the local duties, and the relief of such as return from abroad. At the commencement of a war, although the militia is called out, the reinforcements required to place distant garrisons, on the war establishment, absorb nearly all the infantry, and leave not only no disposable force, but even no sufficient elements to create new corps in an efficient manner. Hence, three or four years of war pass by in preparations on one side, and in conquests on the other. Millions are spent, and vast sacrifices made, to arrest the progress of the enemy; humiliat-

ing offers are made, which the opponent, blinded by success, has the imprudence to reject. Then, forced to still greater expence, other campaigns follow, to recover what was lost in the first. By a rational system of preparation wars might be terminated in a short period, or altogether prevented; and yet long wars, the real cause of the prodigious national debt, are brought about by an ill-judged prejudice against a standing army, backed by still weaker ideas of economy. Since regular armies have been maintained in Europe, the obvious utility of having at least some disposable force to give weight to negotiations, requires scarcely an argument. Instead of three battalions, the only applicable troops in 1792–3, which were sent to Willemstadt, had Great Britain possessed 25,000 disposable troops, the National Convention would have paused before it declared war; or this force would immediately have influenced the reconquest of Belgium. Even a year later, such a national force could have averted the consequences of the action of Hooghlede, the retreat from Dunkirk, and the final evacuation of the Netherlands. In the late war, the inability of Great Britain to act from the first with vigour compelled her to fight twenty-one years, with incalculable waste of blood and treasure, merely to restore the balance of power; and the nation, which at first had only three battalions for service, ended, in 1814, with a mass of more than a million of men in arms.*

In a military point of view, the economical system has been productive of immense losses to the nation; but if, under given circumstances, in time of peace, the army must be very generally reduced, care should be taken not to destroy the elements of regeneration. On a war breaking out, all the troops in the kingdom should be brigaded, with their generals, staff, field train of artillery, commissariat, and medical officers, and concentrated as much as possible, for the purpose of rapidity of execution, and creating habits of duty in large bodies, which the staff and commissariat generally begin to learn when before the enemy,—at a period when all parties should be fully acquainted with them, and when mistakes may be fatal. The orders of Government are thus executed as soon as issued, and that species of confusion is obviated which all who served in the beginning of the late war must have witnessed.

Till the beginning of the present century, plans of operations were usually arranged in the Cabinet, by superannuated officers, on obsolete principles; or by Ministers without professional knowledge, upon combinations entirely political. The Austrian Government was particularly unfortunate in this system. Plans, calculated with the precision of summer manœuvres, where every march, battalion, and detachment were prescribed, without adverting to the measures of the enemy, tied the hands of the generals, who were never successful against a formidable enemy but when they disobeyed their instructions, as Eugene did at Zenta. But when Frederick traced his own plans of campaign, although even he was not fully sensible of the laws which should regulate territorial and manœuvring lines of operations, still circumstances and superior *tact* soon led him into the true system. Jomini blames, with sagacity, some of his initial operations; but he does not sufficiently consider his circumstances and his era; he compares the operations of Napoleon, with all the resources, fortresses, population, and revolutionary excitation of France, together with the adventurous gambling of his hero, to the conduct of a sovereign who had his native throne to defend; without a military frontier, with a scanty population, a barren soil, and no pecuniary means but such as arose from his economy; and yet he rose superior to all the difficulties of his situation, though under circumstances more unpromising than those which ultimately hurled Napoleon from his throne.

II.—*Manœuvring Lines of Operations.*

The connection between manœuvring lines and those which nature has marked out, and the views of the general-in-chief, form separate classes, each named after the nature of that connection.

1. *Simple lines of operations* are those when an army operates in a single direction from a frontier, without forming detached corps.

2. *Double and multiplied lines*, when an army acts upon the same frontier with two or three isolated corps, towards one or several objects.

3. *Interior lines of operations* are formed to oppose several hostile lines, and are so directed as to possess internal connection, and enabled to move and approach each other, without allowing the enemy to oppose a superior mass to them.

4. *Exterior lines*, on the contrary, possess the opposite qualities; they are such as an army may form, at the same time, upon the two extremities of one or several hostile lines.

5. *Lines upon an extended front* are those which are arranged upon a great contiguous developement by isolated divisions; but still belonging to the same mass of forces, and operating upon the same object. Under this head are comprehended, likewise, lines formed by two separate corps upon one given extent; they are then double lines upon a great front.

6. *Deep or lengthened lines* are those which, commencing at their base, pass over a great extent of country before they can attain their object.

7. *Concentric lines of operations* are either several or a single line subdivided, moving from distant points in order to arrive at the same object, in front or in rear of their base.

8. *Eccentric lines* designate a single mass starting from one point, and dividing itself in order to form several diverging lines upon isolated objects.

9. *Secondary lines* are those in the great combinations of two armies, which designate their relative connection while operating upon the developement of the same frontier.

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* According to authentic documents, this mass amounted to 1,116,813, including navy, East India, and local militia force, but exclusive of yeomanry and volunteers.

10. *Accidental lines* are produced in the original plan of campaign, when unexpected events necessitate a new direction for the operations. They are of the highest importance, and rarely adopted but by generals of the first abilities.

Formerly, lines of operations were considered only as they effected the *materiel* of armies; it was even advanced, that armies encamped near their magazines had no lines of operations; but an example will prove the fallacy of this opinion. Supposing two French armies encamped, one on the Upper Rhine in front of Brisac, and the other on the Lower Rhine in front of Dusseldorf, with both their magazines in the safest place, that is, behind the river. These armies must have either an offensive or defensive object, and therefore have territorial, as well as manœuvring lines of operations. 1st, The territorial defensive line will extend from the point of their position to the point which they are to cover; therefore they would both be cut off if the enemy occupied that point before them. If Melas, with his army, could have subsisted near Alexandria in Lombardy, after the battle of Marengo, he was no less cut off from his line of operations as long as his victorious opponents occupied the line of the Po. 2d, Their manœuvring lines would be a double against a simple one, if the enemy concentrated his masses to crush one of the armies; it would be a double external line against a double internal, if the enemy formed also two corps, but so directed that they could be united most readily.

The article in the *Edinburgh Review*, on the work of Jomini, makes the following able remarks on lines of operations: "Among all these lines, the simple and interior are the best, particularly when combined, as being most congenial to the great principle of carrying a mass of troops upon the decisive point. A few remarks will make the truth of this apparent. If an army advances from its base of operations upon one line, it is clear that the general commanding will have but two important dangers to provide against; first, that of his troops being attacked unawares; and, secondly, that of being turned and cut off from his communications with his base. The most effectual method of guarding against either is, to attack the opposing enemy first, or, as the author calls it, *prendre l'initiative;* and if, in so doing, the assailants can place themselves in such a position, that a victory will give them the means of utterly destroying their adversary, while a defeat will not be of material detriment to themselves, the manœuvre must be considered as a perfect one. Now, a single and interior line has a manifest advantage over every other in aiding such an operation. An army which moves upon double, exterior, or multiplied lines, must be weakened in proportion to the number of its divisions. The general has many combinations to attend, and many dangers to guard against; his columns being on many roads and unconnected, must also be dependant upon many persons and many orders. Obstacles will be multiplied at every step; and errors cannot be known or corrected without much loss of time. The success of his plan must depend upon the exactness and concert between the different divisions; a misfortune attending any one vitiates or destroys the whole project, and yet each column, separately, will be too weak to strike an important blow, if a favourable opportunity should occur. They will suffer severely from mishaps, and they cannot well take advantage of misfortunes.

"An army that manœuvres upon simple and interior lines gets rid of all these incumbrances; the troops will be together and well in hand, with the general upon the spot, ready to rectify errors, and to superintend every movement; and upon whichever road he marches against an enemy acting upon double or multiplied lines, his combinations must be more simple, and his numbers must be superior; he will have the power of overwhelming whatever division of his adversary he may meet with, and, by thus disorganizing his opponent's plan of campaign, enable himself to cut off their communications, or to attack their columns in detail. We will suppose, however, that, finding their line penetrated, they might, by great exertions, unite the remainder of their scattered corps by a retrograde movement; but they will hardly be able to cover their communications, which must be nearly as numerous as their divisions, and the attacking army will give battle in the execution of a preconcerted plan, while they will be in the confusion of a baffled one. If the great principle, however, of carrying a mass upon the decisive point has governed the general who advances upon the simple line, he will, by a victory, deprive his foe of retreat, and utterly destroy him; while, if he fail, his communications are still open, and, from want of a plan, the pursuit cannot be very vigorous."

These remarks upon manœuvring lines are well illustrated in modern military history. In the Seven Years' War, Frederick had the choice of attacking Austria, on his left, by Silesia into Moravia, in the centre through Lusatia, and on the right by Saxony, both into Bohemia. His natural territorial line was, undoubtedly, the first of these three; because, while his own flank was covered by the fortresses of Silesia, he could penetrate at once into the vitals of the Austrian dominions, and masking Olmutz, threaten Vienna. He did not feel the advantage of this line until the third campaign, when he was every where outnumbered by the enemy, and yet even then he might have had signal success, if his besieging train, &c. had been in more efficient order and better applied. From this period he became sensible of the superior utility of central lines, and from 1758 he operated successively with his principal mass in Saxony, Silesia, and Brandeburg: the same troops were victorious in all these quarters, by alternately reinforcing each corps so as to attain a superiority. Having missed the opportunity in 1757 of deciding the war by a successful invasion, he at last gloriously saved his kingdom by this new system. All these successes belong to the three first classes of simple, double, and interior lines of operations. Those of his adversaries, on the contrary, were always of the fourth and fifth, exterior lines, and lines upon an extended front. For, on looking at the map of the seat of war, it will be readily observed, that he operated within the triangle formed by Dresden, Breslaw, and Custrin, while the enemy manœuvred outside of that figure. After the battle of Hochkirch,

indeed, when this area was broken in, he made a master stroke, by uniting his three armies in Saxony, and thus wresting from Daun the advantages of his victory. The operations of that crisis belong to the tenth, or accidental lines, in which Frederick has never been surpassed. To this class belong, likewise, his invasion of Bohemia, after raising the siege of Olmutz; his march into Silesia and manœuvres before and after the battle of Liegnitz, in 1760; and his central position at Buntzelwitz, by which he kept the enemy divided, in 1762.

The French operations in Hanover were not more successful. In 1758, they formed two lines of operations, in Hessia and on the Wezer, upon a developement of 300 miles. Prince Ferdinand manœuvring upon their extreme left, had only isolated corps to contend with, and drove them across the Rhine. Marshal Contades, after the battle of Crevelt, felt the advantage of the line of the Rhine, all the fortresses being in his hands; but while he acted without vivacity on his right, Prince Ferdinand took a central direction, and broke the concert between the two hostile armies, who, at the end of the campaign, lost nearly all they had gained, having spent their time in disjointed marches, and in writing *projets* and counter *projets*. After the battle of Bergen, in 1759, the French, grown wiser, united all their forces in Hessia; they made conquests, which even the defeat of Minden did not wholly repair. In 1760, Marshal Broglie persisting in operations in mass, made a respectable campaign, but the next two, armies were again formed at a great distance; Prince Ferdinand again was beforehand with them every where; at length they approached each other to attack, but, for want of concert, were defeated at Fellinghausen.

In comparing the constant difference of the lines of operations which the Austrians, Russians, and French adopted, with those of the Prussians and Hanoverians, their opposite results are at once discovered.

During the wars of the Revolution, the Duke of Brunswick's march into Champaign was a simple line, but wanted corps to cover the flanks and activity in the execution. The recovery of Belgium by the Austrians was also effected by operating in mass; but on the French frontier they wasted their time in sieges, and acted upon exterior and eccentric lines. The French operated in a similar manner, but having a line of fortresses and numerical superiority, they were at last successful, and expelled the allies from Belgium. This worthless system was then cried up, and denominated Carnots. Accordingly, in 1795, the French persisted in acting on double lines. They manœuvred on the Rhine, by Dusseldorf and Manheim: Clerfait operating centrally, carried his masses alternately from right to left; gained the decisive victories of Manheim and the lines of Mayence, and threw the French army of the Sambre and Meuse back across the Rhine to cover the Mozelle, and Pichegru under the cannon of Landau.

In 1796, the French in their lines of operations on the Rhine, still copying Frederick's faulty system of 1757, and their own of 1794 and 1795, were not more successful than the preceding campaign. The armies of the Rhine, and of the Sambre and Meuse, moved from the extremities of their base to take a concentric direction on the Danube. As in 1794, they formed two exterior lines. The Archduke Charles opposed his own in an interior direction to be more readily concentrated, and seized the critical moment, while the corps of Count Latour was covered by the Danube, to steal some marches unperceived by Moreau, and to throw his mass upon Jourdan, who was routed at Wurtzburg. This decided the fortune of the campaign in Germany, and compelled Moreau's deep lines to retreat into France.

Meanwhile Napoleon commenced his extraordinary career in Italy, as Frederick had recommended half a century before: his system was to divide the enemy, and force the Austrians and Piedmontese to take two exterior lines. They fell into the snare, and he defeated them separately at Mondovi and Lodi. An army had assembled in the Tyrol to relieve Mantua; it was led on in two lines separated by a lake (Guarda). The French general raising the siege, hurried with the mass of his forces to meet the first column at Brescia, and routed it; the second column arrived soon after on the same ground, and was likewise driven back upon the Tyrol. Wurmser determined to cover the two lines of Roveredo and Vicenza; Napoleon, after defeating the first and driving it into the Lawis, changed his direction to the right, passed through the gorges of the Brenta, upon the left line of the enemy, and forced the wrecks of this fine army into Mantua, where it ultimately capitulated.

In 1799, the system of Carnot again prevailed. France, twice punished for operating with two exterior lines, now adopted three. An army on the left observed the Lower Rhine, one in the centre was on the Danube, and a third occupied Switzerland. These armies could not unite till they reached the valley of the Inn, eighty leagues from their base. The Archduke uniting his forces in the centre, gained the victory of Stockach, and the Helvetian army was constrained to evacuate the Grisons and Eastern Switzerland. In their turn the allies committed the same fault; instead of pursuing the conquest of this central bulwark of Europe, they formed a double line in Switzerland and on the Lower Rhine. The army in the former country was ruined at Zurich, while that in the latter was trifling about Manheim. In Italy a double line was formed by the French; one towards Naples, where 32,000 men were employed to no purpose; while the other, on the Adige, was too weak, and suffered severe loss. At length, when the army of Naples returned towards the north, it committed the fault of taking a direction from that of Moreau. Suworow took an able central position, marched against the first of these armies, and defeated it within a few leagues of the other.

In 1800 the scene changed again. Napoleon, having returned from Egypt, displayed a new combination of the lines of operations: 150,000 men filed off on the flanks of Switzerland, opening, on one side, on the Danube, and on the other upon the Po. This masterly combination secured immense advantages. Modern Europe had not as yet presented such operations. The French armies, forming two

interior lines, which reciprocally sustained each other, forced the Austrians to take a contrary or exterior direction, which disabled them from communicating together. By this arrangement, the reserve army cut off the communications of Melas with the base, while it preserved all its own, with the army of the Rhine,* which constituted its secondary line. A reference to the map of that seat of war will show Moreau posted at Stockach and Zurich, and Kray facing him on the north side of the Danube. In Italy, Napoleon on the Po, at Pavia, and Tortona, with a corps at Verceil, completely insulating Melas at Alexandria; while the French commander, in case of check, had all the gorges of Switzerland, the St Bernard, Simplon, St Gothard, and Splugen open. The events of that period offer convincing proofs of the decisive effect of a proper choice of lines of operations.

In a subsequent campaign, Napoleon, breaking up from Boulogne, and directing several corps through central Germany to approach the Danube, suddenly turned the position of Mack at Ulm, and, placing himself upon his communication, forced him to surrender. But in this campaign his fortune began to blind him. Forgetting that he had no base of operations nearer than the Rhine, he hurried forward to Vienna, and thence to meet the Russians in Moravia. Prussia was in arms; an English corps had reached the west of Germany; Bohemia had risen in mass; the Tyroleans made a successful resistance; and the Archduke Charles, after crippling the French army of Italy, had advanced to the vicinity of Vienna. At this moment, with only a small reserve at Frankfort, the Austro-Russians, who had every interest to temporize, hazarded the battle of Austerlitz; and his good fortune, and the imprudence of the allies, saved him from a dilemma from which that victory would not have relieved him, but for the pusillanimous feelings which signed the peace.

Similar manœuvres towards the sources of the Saala produced the disasters of the Prussians at Jena and Auerstadt. But in this war, Napoleon became still more enamoured of deep and baseless lines of operations; the baneful effect of which he was not destined to feel till the campaign of 1812, when he invaded Russia without a true base nearer than the Rhine. His secondary base on the Vistula bore no relation to the depth of his line of operations, intersected by the Niemen, the Dwina, and a solitary waste of endless woods and heaths. Although he operated on a simple line, the immense distance from his base left him without communications. The extremes or pivots of the secondary base were already turned and broken, when Kutusoff moved to the rear of his flank upon Kaluga, towards the Berezina, and destroyed the greatest army recorded in modern history. The next year, though his lines were shorter, circumstances were totally altered; he operated with ability in mass; but being greatly inferior in horse, and the allies manœuvring likewise in mass, the first battles were indecisive, till his adversaries, operating upon double exterior lines,—on this occasion applicable from their great superiority in numbers and in cavalry,—moved again round the flank, and decided the question at Leipsig.

Meantime, the Duke of Wellington, in the Peninsula, *cunctando restituit rem.* Opposing a single line against a single line, he saved Portugal by his masterly position of Torres Vedras, without a battle. Next, he drove the enemy from the frontier fortresses, by alternately carrying his masses across the Tagus. His line was shorter from north to south than that of the enemy, and he caused them to increase theirs by the destruction of the bridge of Almeras. Thus he forced his opponents to operate exteriorly. After the victory of Salamanca, his march into Spain was by two interior lines; and though this operation has been blamed, because it ended in a retreat, we forget that the enemy was obliged to abandon the south, or one half of Spain, to produce it. The next operation was upon a single and decisive line. The enemy was encountered at Vittoria before he could concentrate his forces, cut off from his base, and driven headlong into Pampeluna.

Advantageous and Disadvantageous Lines.

This comparison of the combinations and results of the most celebrated campaigns shows, that all the lines of operations that have been crowned with success depended on general principles, of which the following are the principal heads.

1. A double line of operations is advantageous, if the enemy has, likewise, a double line; provided theirs be exterior, and at a greater distance than yours, and unable to unite without first risking a battle.

2. An army possessing interior lines, more connected than those of the enemy, can, by strategical movements, destroy them successively, by carrying the mass of forces alternately upon each point, as exemplified in the campaign of 1758, and subsequently at Manheim and the lines of Mayence; at Wurtsburg and Emmendingen; at Lonato and Castiglione; Trente and Bassano; at Stockach and Zurich; Abendsberg and Eckmuhl, &c.

3. In order to effect this movement, a corps should be left before the army which it is intended to keep in check, with orders not to engage, but merely to retard the march, by taking posts behind defiles or rivers, and retreating towards the army.

4. From the above premises, it follows that a double line of operations against an enemy, whose corps are in closer connection, will always be unfortunate with equal numbers, if the enemy profits by the advantages of his situation, and manœuvres with rapidity within it.

5. A double line of operations becomes still more dangerous, when its parts are separated by several days' march.

6. Simple and interior lines, on the contrary, are always most safe; because they admit the action of

* Army of the Rhine, of the Sambre and Meuse, were names given to French armies, although they were not always on these rivers.

the mass of forces against the isolated divisions of the enemy, if he be so imprudent as to venture an action.

7. A double line of operations, however, may be adopted with success, if the forces employed are so much greater, that superior masses can be presented to the opponents on both its parts.

8. Two interior lines, mutually sustaining each other, and facing two exterior lines at a certain distance, must avoid being compressed into a small area; for the exterior hostile lines might thereby act simultaneously.

9. Again, they should not operate at too great intervals; for the enemy might have time to crush one of these divisions, while it is weakened by detaching to the other, and thus gain a decisive advantage.

10. It being the interest of a commander to divide and isolate the opponent's forces, his manœuvring lines should never have the object of drawing the whole hostile forces upon him; as Tempelhoff boasts Frederick to have done in the campaign of 1760.

By reference to the preceding sketch of the operations in late wars, the value of these rules is everywhere observable. When the details in history are examined, such as they are presented by authors acquainted with the art of war, they form a key, which opens an unerring way into all the causes of success and misfortune. Thus, in what has been said on accidental lines of operation, it might have been added, that Napoleon did not know how to avail himself of them, when he was advised to operate by the right bank of the Elbe, and change his direction upon the pivot of Magdeburg, instead of risking the battle of Leipsig, and suffering, in violation of the eighth rule, the enemy to place him between two fires. Nor, in Champaign, in 1814, when he operated at too great a distance, overlooking the ninth rule, which gave the allies time to force the gates of Paris, thus employing the just system of throwing the mass of their forces upon the most important point. The Duke of Wellington's defensive campaign in Portugal hinged upon a prudent application of the second rule; and Napoleon, in 1814, could not have resisted so long as he did in France, but by the same system; although the allies, at that moment, conducted their operations on the seventh rule, perfectly applicable under the then existing circumstances, yet the vast superiority of internal lines remained evident. But when his eccentric movement placed him out of the sphere of real operations, the allies applied the third rule with perfect success, and effected his fall.

In order to complete the view of territorial and manœuvring lines, it is requisite to consider them as they are affected by the configuration of frontiers.

1. In order to operate with advantage, there should not be two different armies upon the same frontier: because,

2. Double lines will always fail, with equal chances, against a single line, as has already been shown.

3. Interior lines resist with advantage against exterior lines, either upon the same, or upon two different frontiers. The objection that Pichegru proved successful in 1794 is not valid; because Prince Coburg did not avail himself of his interior line, but acted by detachments, while he remained inactive with his mass, inferior in strength, and unsupported by fortresses on the flanks.

4. When the hostile fortresses are scattered upon a line of great extent, the most advantageous manœuvring line is upon their centre; as the Russians experienced to their cost, in the beginning of the campaign of 1812: but on all other occasions, the best direction is upon one of the extremities, and from thence on the rear; as exemplified in 1800, in Italy; in 1805, in Bavaria, and the next year at the sources of the Mein and Saala, &c. When central masses are moved with ability against scattered corps, all other things being equal, they must always be successful, often even without a battle: as when Moreau making demonstrations against the left of Kray, near Huningen, moved rapidly into Switzerland, whereby the greater part of Swabia fell into his hands without an action. The march of the Duke of Wellington upon Madrid and Burgos produced the immediate evacuation of the south of Spain; and the movement of Kutusoff upon Kaluga, forced the French from Moscow and out of Russia.

5. The configuration of a frontier may have important influence on the direction of lines of operation. Central positions, forming salient angles towards the enemy, such as before observed, Bohemia forms towards Prussia, Switzerland towards Austria or Saxony, as it was circumstanced in 1813, are the most advantageous; because they are naturally interior, and lead to the flanks and rear of the opponent's defensive line. The sides of these salient angles are therefore so important, that all the resources of art should be added to those of nature to render them impregnable. Switzerland and Bohemia are sufficiently proved to possess these natural advantages; but Saxony appears more doubtful, because Napoleon was at length defeated at Leipsig. Yet, it was his conviction of these central advantages that made him neglect to change the line of his operations upon the pivot of Magdeburg: and if we examine the character of the operations, though the allies were numerically, and especially in excellent cavalry, superior, we discover that when his defensive manœuvres were confined to a moderate distance from the Elbe, and the ridge of the mountains of Bohemia, no impression could be made upon him; but his system was solely that of attack, and his impatience sought the Prussians deep in Silesia, the grand army beyond the defiles of Bohemia, and the northern army in the sands of Berlin; not successively, but all at the same moment. He was thus on all sides inferior, but not dislodged, till, by his own indecision, he allowed the enemy to turn both his flanks simultaneously, and to bring him to action between two fires at Leipsig. We may take occasion to revert once more to the double exterior lines of the allies, here, and in 1814, in Champagne. When each of the armies operating exteriorly amounts to 120,000 or 150,000 men, they possess a consistency which obviates all need of co-operation: for, admitting the enemy to be even stronger, there is not a great dis-

parity of force between the parties, which can be deployed and brought into action on the same field of battle: hence the weaker army can decline a battle, and in both these cases, where the allies had great superiority of cavalry, they could begin and break off a battle at their pleasure; as they proved at the first battle of Leipsig or Lutzen, and at Bautsen.

6. Where no such central position or territorial projection exists, the same effect may be produced by the relative direction of the manœuvring lines, as exemplified in Plate CXXI. fig. 1. C D, manœuvring on the right flank of the army A B, and H I, moving upon the left flank of F G, form two interior lines, C K and I K, upon the extremities of each of the exterior lines, A B and F G; both of which may be destroyed by carrying the mass of forces alternately upon them. This combination presents the effect of the French campaigns of 1800 and 1809. It is also the spirit of the Duke of Wellington's defence of Portugal; for by his bridges on the Tagus, he had a direct and interior communication on both his lines north and south of the river, while the enemy, being placed on the segment of a circle, had only the precarious connection by the bridge of Almeras, which being destroyed, he could not advance from either Andalusia or Salamanca, without immediately placing himself in the disadvantageous position here described.

7. The configuration of the theatre of war may possess the same importance as that of a frontier; for, in fact, every theatre of war may be considered as a quadrilateral figure. To elucidate this idea, the scene of operations of the French army from 1757 to 1762, and the operations of Napoleon in 1806, may be cited. In Plate CXXI. fig. 2, the side A B being inclosed by the North Sea; the side B D by the river Wezer,—base of the army of Prince Ferdinand; C D representing the river Mein,—base of the French, and A C the Rhine, likewise in possession of the French; their armies operating offensively on the sides A C and C D, had the third A B or North Sea in their favour, and therefore B D was the only side, which they were to gain by their manœuvres, to have possession of the four sides, and consequently of the base of all the communications of their adversary.

This is more clearly exemplified in fig. 3. The French army E, proceeding from the base C D, to gain the position F G H, cuts off the allied army J, from the side B D, its only communication and base. It would thus be driven into the angle L A M, which is formed near Embden by the line of the Rhine, the Ems, and the Sea; while the army E could always communicate with C D or the Mein.

The manœuvre of Napoleon, on the Saala, in 1806, was combined on the same principles. He moved upon Jena and Naumburg in the position F G H; and then advancing by Halle and Dessau, he threw the Prussian army J upon the side A B, formed by the sea. The fate which attended that army at Erfurth, Magdeburg, Lubeck, and Prentzlow, is well known. The great art, therefore, consists in combining the marches, so as to arrive upon the communications of the enemy, without sacrificing one's own. Now the lines F G H, by means of the prolonged position, and the angle formed towards the extremity of the enemy, always preserves the communication with the base C D. This constitutes the application of the manœuvres of Marengo and Jena.

When the theatre of hostilities is not near the sea, it will be still circumscribed by some great neutral power which guards the frontier, and incloses one side of the quadrangle. No doubt this barrier is inferior to the sea, but, in a general view, it must nevertheless be considered as an obstacle, upon which it is dangerous to be driven after a defeat, and advantageous to push an enemy. A state with 200,000 men will not suffer its neutrality to be violated with impunity; and if a beaten army ventured so to do, still it would be cut off from its base. But if an inferior power forms the limit of the theatre of war, the square of operations may then be considered as extending over it to the next great neutral power, or the sea.

To give a still more convincing proof of the justness of the preceding ideas, let us examine the scene of the campaign of 1806-7, in Poland. The Baltic and the frontier of Austrian Gallicia formed the two sides A B and C D of the above square. It was of great consequence to both parties to avoid being driven upon either of these obstacles. The configuration of the frontiers may modify the sides of the square, and convert them into a parallelogram, or a trapesius, as in the 4th figure, Plate CXXI.

In this case, the army G H being in possession of the sides A C and C D, would be still more favourably situated, because the base of the opponent being contracted at B D, would be more difficult to keep open. The front of the base B D having less extent, offers fewer resources for manœuvring, and affords to the army G H the means of operating with more success; because the direction of the line C D naturally leads upon the communications of the enemy, and because the space to be occupied in order to cut him off, is shorter, and therefore more easily held with concentrated forces.

The theatre of war in Prussia and Poland, previously mentioned, was precisely of this figure. The frontiers of Austrian Gallicia extending to the Narew, formed by the line of the Vistula, the contracted side B D; and the manner in which Napoleon embraced that line at Pultusk and Eylau was similar to the figure here shown. This operation had, however, its unfavourable chances. The first depending upon the doubtful trust to be reposed in the neutrality of Austria, and the second upon the great distance from the base of operations, which exposed the communications of the armies with the Oder to the mercy of the Cabinet of Vienna. It depended even then upon Austria (as, indeed, it had the year before depended on Prussia) to put a stop to these endless invasions. The manœuvre of the French general was good, but the operation of the statesman was only daring. These examples are sufficient to demonstrate, that the manner of embracing a theatre of war is amenable to the two following principles.

1. To direct the masses upon the decisive points of the line of operations, that is, upon the centre, if

the enemy has been so imprudent as to scatter his forces, or upon an extremity, if he is in a contiguous line.

2. To make the great effort in the latter case upon that extremity, which has its back against an insurmountable obstacle, or which leads upon the communications of the enemy without sacrificing our own.

Defensive Operations.

Defensive operations, in a great measure already examined in the preceding discussions, require, nevertheless, some further remarks. Passive defence offers no security to a state, nor fortresses without an army; it is confiding in a shield without a sword. Reason and experience alike prove, that defensive system to be the best, which embraces the greatest number of offensive facilities; for these we refer, in particular, to interior and simple lines; and those directions of lines which best anticipate or counteract the most effectual offensive ones. But as defensive measures imply inferiority of forces, they must in a considerable degree depend upon local means to counterbalance the superiority of the enemy. Rivers and chains of mountains are the natural obstacles; fortresses, intrenched camps, and well selected positions upon the most advantageous lines of defence, the artificial means in a territorial front. Fortresses, with *tetes de pont* upon a river parallel to the frontier, are very advantageous; but upon a river perpendicular to the frontier, they are still more useful; particularly if fortified upon both banks, as Prague on the Mulda, or Maestricht on the Meuse. In the former case, an offensive army must cross the river only once; but in the latter, it must cross as often as the adversary thinks proper: for, placing his camp under protection of one of these fortresses, the enemy cannot pass him, without being taken in flank or rear; nor besiege the place without dislodging the enemy. Hence, intrenched camps, covering and covered by a fortress, add considerably to the defence of a state. The Austrians felt severely the want of these precautions on the Danube in the late wars. Thus the operation of Mack upon Ulm would have been good had he moved in time to attack from thence either on the right or left of the river; but to have rendered it secure, there should have been fortified positions on the Schellenberg at Donauwerth, Ingolstadt, and Ratisbon: for then he could always place the river between him and the enemy; and if the latter operated on both banks, he could attack, with his whole mass, that part which was most convenient, before the other could cross to assist it. Fortifications are also eminently useful in the defence of passes in chains of mountains. The insignificant fort of Bard, with 600 men, arrested the progress of the principal column of Napoleon, when descending the Great St Bernard into the valley of Aoste, in 1800; and if the fort had been better secured, the whole plan of campaign would have failed; for Melas would have had time to arrive and defeat the enemy in detail. Again, the French Emperor having constructed the fine roads into Italy, neglected to secure them by any fortifications, and the first military use that was made of them was by the Austrians, in the two successful invasions of France, where the old fort of L'Ecluse, near Geneva, was the only point that could, and actually did, retard them some days.

Fortresses likewise secure the magazines, stores, and hospitals of an army, and save the *materiel* and broken troops after a defeat. Pampeluna saved what did escape of the French after the battle of Vittoria, as Prague did the Austrians in 1757. But, in order to make them capable of producing the share of security to a state which reason can expect from them; fortresses should not be too numerous, because they absorb too great a proportion of troops for garrisons, and cost immense sums; nor small, for then they are easily embraced and overpowered by artillery; nor all on the frontiers, for if the enemy penetrate beyond them, the great arsenals, depots, founderies, &c. of the nation are no longer within reach of the defensive army, which is also deprived of the *appui* for a position to cover the capital, and turn the flank of the invader. In the last campaigns, France felt the want of intermediate fortresses. If such had existed about Soissons, on the Marne, and about the junction of the Seine and Aube, the avenues to Paris would have been more easily defended. Intrenched positions are often eminently useful, provided they intersect or flank the most direct lines of operations; but as they do not contain arsenals, &c. they are less so than fortresses, and the selection of their site is extremely difficult. Those of the Russians at Drissa, upon the line of Moscow, were abandoned. The intrenchments of the French on the frontiers of Spain, and at Toulouse, were forced; but those on the Isla near Cadiz, and at Torres Vedras, both saved kingdoms. A position ably chosen has sometimes the same effect. That of Dumouriez, near the wood of Argonne, arrested the advance of the Duke of Brunswick in 1792; and that of Kutusoff at Malojaroslaf near Tula, forced the French to retire by the road they came. Both were on the flank, and menaced the rear of the enemy. Dumouriez, in the north-east corner of the French frontier, presented a salient angle, upon a simple line of operations towards the German and the Netherland fronts of defence, and was near the fortresses of Lorrain. Napoleon, in 1814, endeavoured to recover a similar line after the battle of Brienne; but it was then beyond the sphere of operations, and his march cost him the loss of his empire. To conclude, defensive war does not consist in covering every part of a state, but *in preventing an enemy from obtaining any advantage, which may enable him to accomplish his main object.*

III.—*Battles.*

Between a battle won and a battle lost there is an immense distance, said Napoleon, the day before the conflict at Leipsig—empires lie between them; and, indeed, the plan of campaign, and the strategical movements, are only so many preparatory dispositions to arrive at the great crisis of a battle. The rules applicable to battles, therefore, form the most important branch of the science of war; because, unless they are well understood, all other knowledge will be comparatively useless. In many respects, this branch is less capable of being reduced to fixed principles than the others. There are,

War.

however, certain general rules, which should govern the dispositions, and the chance of success will be increased or diminished in the ratio of their due application. Among these, the first is that of operating with a superior mass upon the decisive point, because the physical force of organized numbers in arms furnishes the unerring means of victory, when the moral qualities in both armies are equal. The means of bringing this force to bear in the most advantageous manner is the art of fighting; consequently, courage and fortune being nearly balanced, that general who can operate with the largest mass upon the most decisive point must be successful. But to effect this purpose, the combinations must be such as to produce a unity of movements, conducing simultaneously to the same object.

The following maxims are of general application: 1. No opportunity should be left till the morrow. 2. No battle should be given, but for an important object, unless the position should render it unavoidable. 3. After a victory, the enemy should not be allowed to recover—the pursuit should be incessant.

As in lines of operations, so on fields of battle, it is necessary to avoid dispositions, which have generally proved fatal; such as, 1st, forming isolated divisions; 2d, ordering extended movements, which deprive the army of a part of its strength, and enable the enemy to ruin either the main body or the detachment; 3d, positions with too great an extent of front; 4th, allowing obstacles to separate the wings, or obstacles which prevent the connection of columns, and expose them to separate defeats.

The finest combinations are those which produce an oblique order of battle; those with a wing reinforced; those which out-flank the enemy; and those which form a perpendicular upon a hostile extremity, or upon a scattered centre. These are almost always successful, because they present a whole line to an extremity; and, therefore, a greater mass than the enemy. Thus the fundamental principle of all military combinations; namely, *to effect with the greatest mass of forces, a combined attack upon the decisive point*, is applied; and it is easy to understand how a general of ability, with 60,000 men, may be able to defeat 100,000, if he can bring 50,000 into action, upon a single part of his enemy's line. For battles are decided, not by troops upon the muster rolls, nor even by those present, but by those alone who are simultaneously engaged. Numerical superiority of troops not engaged, so far from being useful, only increases the disorder, as was fully exemplified at Leuthen.

There are not a great variety of measures applicable to this maxim.

I. The first is evidently that of taking the lead in the movements. The general who is enabled to have this advantage, can employ his forces wherever he thinks them applicable; while, on the contrary, he who is obliged to await the enemy, is no longer master of a single combination; because his movements must be subordinate to those of his adversary, and it is too late to arrest them, when they are already executing. The general who takes the lead knows what he intends to perform; he conceals his march, surprises or overpowers an extremity or a weak part of the hostile line; while the waiting army is defeated on one of its points, before the knowledge of the attack has reached its commander. Hence the following are corollaries.

1. An army taking the lead in a movement can conceal it until in full execution; therefore, when the manœuvre takes place in the interior of its own line of operations, the commander may gain several marches of the enemy.

2. To judge soundly of military operations, it is highly important to banish all calculations which suppose that the hostile general will be informed of a movement, and will oppose it by the best possible manœuvre, from the instant that the movement is begun.

3. When two armies combine to place the enemy between two fires, from the distance of several marches, they must ground the disposition upon a double line of operations against a simple one, and expose themselves to be defeated separately, if the enemy takes advantage of his central position. Such a manœuvre is similar to a movement made at a distance against the flanks; and should be ranged among those which cannot produce a simultaneous effect at the moment required.

II. The second consists in directing the movements against a weak point of the enemy, when that point offers the greatest advantages.

An attack to the front is always to be avoided, if a concentrated effort can possibly be made upon the extremity of an enemy's line, for which simple demonstrations on the front are sufficient.

Against double and scattered lines of operations, it is preferable to direct the attacks upon the central points; for the mass of forces having ruined a central division, the corps to the right and left can no longer operate in unison, and are forced to retreat eccentrically; as was proved in the disasters of Wurmser, Mack, and the Duke of Brunswick. Against simple lines of operations and contiguous lines of battle, the weak points are the flanks, because they are liable to be crushed before they can be sustained. Albuera offers, perhaps, the only positive example to the contrary in modern history. For here, the right wing of the allies was turned and routed, and yet the battle gained, by the centre forming an echellon to the rear.

A deep column being attacked on the head, is in a similar condition as an extremity of a line; both the one and the other are engaged in succession and defeated, or what is termed rolled up. This was proved at Rosbach and Auerstadt. It is, however, more practicable to make a fresh disposition from a column, than with the extremity of a line, when attacked by the enemy.

In executing a general strategical movement against an extremity of an enemy's line of operations or of position, a mass is not only brought to bear against a weak point, but also, from that extremity, it becomes easy to gain the rear and communications, either of the base or of the secondary line of the opponent. Napoleon's manœuvre in 1805 by Donauwerth and the line of the Lech, turned the

line of communication of Mack with Vienna, which was his base; and it intercepted his connection with Bohemia, which was his most important secondary line, by which he expected the assistance of the Russians. Such were also the views of Soult when he turned the allies at Albuera, and of Junot in his attack upon the flank and rear of the British at Vimiera. Napoleon performed the same manœuvre against the Prussians in 1806 by Saalfeld and Gera; Kutusoff in 1812, by Kaluga and Krasnoi; the grand allied army in 1813, when it debouched from Bohemia upon Dresden and Leipsig; and Napoleon finally attempted it in 1815 by Wavre.

1. But if it be intended to remedy the deficiency of numbers by acting with all the forces upon a single point of the enemy's line; that line being contiguous, the point selected should be as far as possible from the centre, because the centre can be sustained immediately from both the wings; while, on the contrary, an extremity can only receive succours by degrees from the divisions nearest at hand.

2. An attack upon the centre is never advisable excepting when the hostile line is very extensive, and scattered into separate divisions; then, indeed, the result must be successful from the same causes, and the consequences even more brilliant, because the enemy's corps will thereby be totally separated and disabled from re-uniting; whereas an attack upon the flank can produce similar success only under particular circumstances.

III. The result of the preceding truths leads to the maxim, that as it is better to attack the extremity of a line, yet that both the extremities should not be attacked at the same time, unless there be a very great superiority on the part of the assailant. An army of 60,000 men forming two corps of 30,000 each, for the purpose of attacking an enemy equally numerous, is deprived of the power of striking a decisive blow; because it enables the adversary to take equal measures, or even, if the movement be extended and unconnected, to assemble his mass against one of the divisions, and destroy it, by his momentary superiority. Multiplied attacks by means of a greater number of columns are still more dangerous,—more repugnant to the best principles of war; particularly when they cannot commence acting at the same moment, and upon the same point. But when there is a very great superiority of force on the side of the assailant, then indeed both the extremities of the hostile line should be attacked, because thus a greater number of troops is brought into action on both his wings; whereas if this great superiority were kept in one mass upon a single point, the adversary might deploy as many as the other party could bring into action, and thus engage with equal numbers. In this case it is only requisite to collect the greatest mass upon that wing where the greatest success is expected. Daun manœuvred in this way at Hochkirch, and the whole allied forces at Leipsig.

To illustrate this maxim more fully, it is necessary to enter into some detail, and fix a few particular principles. If 50,000 men, intending to attack 60,000, should form two corps of nearly equal force, and with a view to embrace both the extremities of their line, should extend and isolate the attacks, it is clear that the 60,000 will have the facility of moving more rapidly within the interior of their line, than the assailant's corps with such a mass between them; as Plate CXXI. fig. 5, demonstrates. The two corps B and C might gain momentarily some ground, but the enemy A, leaving a corps to check C upon the most advantageous ground for defence which its position might offer, could throw the remaining mass of forces on the front, flank, and rear of B, which must consequently be destroyed. If B and C should have a third detachment on the centre, the result would be still more disastrous, for then separate corps would attack without union, a force everywhere imposing, which could not fail to overpower them. This took place at Kollin, from inattention to the orders of the King; at Neerwinden in 1793; and at Stockach in 1799, where Dumouriez and Jourdan were defeated by Prince Coburg and Archduke Charles. At Krevelt, a similar result would have occurred if the French army had been ably commanded, and exercised in great manœuvres. At Blenheim all Eugene's efforts were unavailing, even when he had gained the flank, until Marlborough's success decided the victory.

The truth of these observations is so manifest, that it may be applied to an army superior in numbers: 50,000 attacking in this manner an army of 40,000, would still incur all the same risks; and if the inferior force, after leaving a corps to mask one attack, should take a rapid offensive measure, and overtake the enemy in his preparatory dispositions, which would necessarily be calculated upon the principle of finding the opponent in his position, the heads of his columns might be turned, and completely routed. But if the two hostile attacks should have between them some difficult object, a wood or river, they might each in their turn be destroyed. Examples of this kind occurred at Lonato, Castiglione, Abendsberg, Eckmuhl, and Ratisbonne.

When, however, the attacking army is double the force of the enemy, the principle no longer holds as stated in the cases of Hochkirch and Leipsig; but, to avoid the danger of divided forces, it is requisite to have the lead, and to conceal it in such a manner that both attacks may commence nearly at the same moment. Thus two maxims, in appearance contradictory, are derived from the same principle.

1. An army intending to attack another of equal or superior force, cannot insure success but by a concentrated effort upon a single point of a weakened line, which is not in a condition to be timely supported.

2. But when a superior army attacks one much weaker, two or three divisions should be formed, in order to bring all its masses into action against the inferior masses opposed; for if the attack were confined to a single point, the whole of the forces could not be brought into line, and the enemy might deploy an equal number; but it is necessary that the whole combinations centre on the same ground, and at the same instant, to produce unity of execution, and avoid partial and successive defeat.

3. As every front of operations and each position

of battle contains a decisive point, it is important that the repartition of forces insure not only a general superiority over the enemy, but also that a strong reserve be appropriated to support the attack upon that principal point.

These maxims are more especially applicable to battles than to strategical operations; for, with these, no necessity demands that corps, acting at the distance of several marches from each other, should engage exactly at the same hour—and it would be impossible so to do on the same ground. But if the principle is to be enforced differently, it is still of full efficacy. It may appear that in these ideas, the main stress of the argument rests upon the local superiority of numbers; but it is nevertheless true, that their combination is the chief object; for 30,000 men may be defeated by half their numbers, if, in the disposition, and in the choice of the ground, some vicious arrangement take place, which produces a real disadvantage;—such as La Motte experienced from Webb, at Wynendael and Chevert, from Imhoff, at Meer; and the Austrians from Moreau, in the defiles of Hohenlinden.

IV. In the strategical movement of a great mass in a combined effort upon one point, it is advisable to keep the forces concentrated, within a space approaching to square, so as to have them perfectly dispc:able; or, in other words, that the depth of the disposition be nearly equal to the front, enabling the battalions to arrive with promptitude from all quarters towards the point attacked. Extensive fronts militate as much against good principles, as great detachments and isolated divisions deprived of the means of being sustained. The inattention of Napoleon and Ney to this maxim gave Benningsen the advantage at Eylau; and the care of the allies in 1815, notwithstanding the difficulty of guarding an open frontier, enabled them to concentrate their masses at Waterloo.

V. One of the most efficacious means of applying the above general principles, is to induce the enemy to take contrary measures. By means of small corps of light troops, jealousies may be created for some important points of his communications. If he can be persuaded that they are formidable, he will be tempted to detach strong divisions against them, and scattering his forces, be disabled from acting with vigour himself, and be exposed to an attack from superior forces. Operations by detachments have, nevertheless, been in fashion. To divide and subdivide, till the main army was reduced to the secondary character of mere observing, was considered as the very summit of strategical science. In the Hanoverian campaigns, the French, with two great armies, acted upon this system; nor could they ever be undeceived, although Prince Ferdinand, with less than half their force, contrived not only to reconquer the country, but afterwards to keep them constantly at bay, and even to attack them with superior numbers. The Austrians, and the army of the empire, operated similarly in Saxony, and reaped similar fruits. But Mack, trained in the Turkish wars, was the great patron of cordons and scattered posts, with inert positions to sustain them. The Austrians have, however, little reason to exult in the success of their system. The least mischief which they have derived from it was, that they fought on accessary points, while the main armies, reduced in strength, were unable to do more than menace the principal objects of the campaign, wasting their time until they were attacked by superior forces.

Nor are hostile armies destroyed by merely taking positions upon their communications, and remaining inactive within them. Had Napoleon halted upon the Lech in 1805, or on the Saala in 1806, he could neither have prevented the escape of Mack, by Donauwerth, nor the retreat of the Duke of Brunswick to the Elbe. The art of war does not consist in incursions upon communications, but in placing the mass upon them, in order to attack the enemy with decided advantage. Detachments upon the communications of the adversary are only accessories of secondary utility.

VI. When the lead is taken in a decisive movement against the enemy, great importance is attached to an exact knowledge of the positions and movements which he may undertake. Spies are then of the utmost consequence; but the use of partisans, thoroughly versed in watching the enemy, is of still greater utility. For this purpose, the general should scatter small parties in all directions, and multiply them with as much care as he would show to restrain them in great operations. Some divisions of light cavalry, expressly organized for this service, and not included in the order of battle, are the most efficient. To operate without such precautions is to walk in the dark, and to be exposed to the disastrous consequences which may be produced by a secret march of the enemy. Generally speaking, these measures are too much neglected. The *Espionnage* is not sufficiently organized beforehand; and the officers of light troops have not always the requisite experience to conduct their detachments.

The Cossacks under Platoff, Chernicheff, Tettenborn, &c. in Russia and Poland; these, with the Prussians under Lutzow in Germany and France; and the Guerillas of Mina, the Empecinado, and others in Spain and Portugal, have shown the immense advantages to be derived from their services. While they were few in number, their real importance was not fully understood; but when 15,000 or 20,000 of them appeared in the field, especially in a friendly country, they became the most formidable enemy, with respect to the combinations, which a general could encounter; because those were always liable to be disjointed, by the uncertainty of the timely arrival of orders. Every convoy demanded a numerous and well-conducted escort, and every march was endangered by the want of real information, relative to the hostile positions. The duties, greatly multiplied, exhausted a great part of the army; and the regular cavalry was soon rendered unserviceable by their excessive fatigue.

VII. It is not sufficient for a good operation of war to convey with ability the mass of forces upon the most important points; they require, moveover, to be brought into action. If they remain inactive when arrived upon those points, the principle is forgotten; for the enemy may make counter-movements

to defeat the project; and it is therefore indispensable that, from the moment his communications or his flank are gained, the mass of forces must march up to him and attack. This is the moment when a simultaneous employment of the troops must take place. Masses of troops present do not decide battles, but the acting masses alone have effect; the former, indeed, produce that consequence in strategical movements, but the latter determine the success of the action.

To insure this result, a general of ability will seize the proper moment to force the decisive point of the field of battle, and combine the attack in such a manner that all his forces will be brought into action, with the exception always of the reserve. But if the efforts emanating from this principle fail of the desired success, no other combination remains than a simultaneous general onset, in which the reserve is then to be brought forward, to make a last and decisive effort.

VIII. We now come to battles proper, all the combinations of which are reducible to three systems.

The first includes defensive battles, where the enemy is expected in a strong position, with the simple object of maintaining the ground. Such were the positions of Tallard at Blenheim, Villeroy at Ramillies, Marsin at Turin, Daun at Torgau; and the events are sufficient to show their general disadvantage.

The second is the opposite system, wholly offensive. It consists in manœuvres of attack wherever the enemy may be found, such as those of Marlborough at Blenheim, Ramillies, and Oudenaerde; Frederick at Leuthen, Zorndorff, and Torgau; Napoleon at Jena and Ratisbonne; Wellington at Vittoria, and the Allies at Leipsig.

The third offers, in some measure, the middle term between the other two. It consists in selecting a field of battle, carefully reconnoitred beforehand in its strategical applicabilities and advantages of ground; then to wait the enemy's attack, and to fix upon the proper moment of passing from the defensive into offensive measures with the best chances of success. In this class must be reckoned the combinations of Napoleon at Rivoli and Austerlitz; of Blucher at the Katsbach and Laon; and of Wellington at Salamanca and Waterloo.

It is difficult to prescribe fixed rules by which the choice of any of these systems should be guided. The circumstances of the moment, the moral character of the troops, considered as affecting their courage, discipline, and inclinations, their national temper, and the conformation of the ground, must be taken into account.

1. Under these general considerations, it may be fixed, that the best mode is to act offensively on all occasions, when the troops are inured to war, and the ground presents no extraordinary features.

2. Where the topography of the field of battle is difficult of access, either from natural or artificial causes, and the troops of different nations not having the same unity of feeling and of discipline, it will be preferable to receive the attack in a position previously selected, with the determination of assuming the offensive when the enemy shall be exhausted by the first efforts.

3. When the strategical circumstances of the parties are such, that one is obliged to attack the other without considering localities; as, for instance, to prevent the junction of two hostile armies, or to crush an isolated corps, &c.

4. When particular circumstances, as extreme inferiority of numbers, forbid any other than strictly defensive measures; such as Eugene took at Chiari, Abercromby on the Zyp, and Moore at Corunna.

Battles in general, whether offensive or defensive, notwithstanding all the varieties of ground and changes of position, may be classed into three systems of disposition, or what are termed *orders*, each subject to some modifications.

First, the simple parallel order, or that in which hostile armies are drawn up in parallel lines, to advance or receive the attack. Jomini justly observes, that accident or superior valour alone decide the contest in this class of orders, and that the soldier is entitled to all the credit; because such a disposition being the fruit of ignorance and incapacity, the general can have no part in it. Notwithstanding this censure, it is somewhat singular that the only battle in which a considerable British corps was severely handled was of this description, when Berwick defeated Lord Galway at Almanza.*

The second order is the parallel, reinforced upon one or several parts of the line. In this class, especially if dispositions with an angle to the front or rear are included, most of the great victories of ancient and modern times may be reckoned. For although it is not the most perfect in theory, it is the most constantly applicable in practice; under almost every possible character of ground, or counter disposition of the enemy.

The oblique order of battle is the third and the best class of tactical dispositions; but in the application, great simplicity of combination is necessary, and great prudence in the execution. Against a manœuvring army ably commanded, it will always be very difficult to apply it; but when produced, the effect is instantaneous and decisive: it is the triumph of discipline and of grand manœuvre.

IX. Orders of battle, or the most appropriate disposition for leading troops into action, should possess the inherent qualities of mobility and solidity. To attain these two objects, troops which are to remain on the defensive should be partly deployed and partly in columns, as the allied army was at Waterloo, or the Russians at Eylau; but the corps destined to attack a decisive point should be disposed into

* Accident, it must be owned, had a great share in this battle; for it is asserted that the statue of St Antonio, the nominal commander-in-chief, was shattered by a cannon ball, which instantly caused the Portuguese to retreat, and leave the British and Dutch to their fate.

two lines of battalions, formed into columns of more or less density. Jomini proposes columns of grand divisions (according to the French formation of a battalion of six companies, making three grand divisions):

6	5	4	3	2	1	
——	——	——	——	——	——	Battalion.
——	——	——	——	——	——	
——	——	——	——	——	——	
12	11	10	9	8	7	
——	——	——	——	——	——	Battalion.
——	——	——	——	——	——	
——	——	——	——	——	——	

Three grand divisions would thus form three lines, and the second line three more. This order, according to his view, offers much more solidity than a deployed line, which waves too much, retards the impulse necessary for attack, and prevents the officers from managing their men. In order to facilitate the march, obviate the great density of the mass, and procure a greater front, the divisions should be formed only two deep; for thus the battalions will be more moveable. The march in front, three deep, is always fatiguing to the centre rank, which, being pressed between the first and third, produces fluctuation, and consequent faintness in the onset. In this manner, all the desired strength will be produced; the three grand divisions giving a depth of six ranks, which is more than sufficient; and the front being one-third longer, augments the quantity of fire, if it should become necessary to use it. The enemy, likewise, will be awed by a display of greater numbers, and the artillery will have less effect than upon more solid masses.

If the proposal of Jomini were applied to the British system of battalion, the same effect would be obtained by fronts of wings of battalion, each three deep. What is said of fluctuation in the march is, indeed, true; but the lock-step is never, and cannot be, observed in a charge or rapid advance to the front in action. The ranks open in those cases sufficiently to allow freedom of step. Firing three deep, though practised at drill, is, in truth, when applied in battle, not more efficient, perhaps less than in two ranks. If, therefore, the expedient of forming battalions only on two ranks be resorted to, still the fronts of wings covering each other, and producing only a depth of four men, would be sufficient for troops so eminently qualified for battle as the British. This proposal of Jomini is an avowal of the inefficiency of dense columns, as they are usually formed by the French and other continental armies, in attacks and charges. If that General had been engaged against the British, he would have been still more convinced of this. During the late wars, not an instance occurred where a hostile *column, au pas de charge,* broke through a British *line.* And the charge at Maida, by a brigade of light infantry; at Barossa, by the 87th, and three companies of the guards; at Vimiera, by the 50th; and at Waterloo, by the whole line—all in deployed order, two deep only, against lines or columns, demonstrate the error of supposing, that a mass of human beings, possessed of individual will and feelings, can be subjected to the laws of mechanical action.

Rogniat, General of Engineers, in the dispositions of the legion which he proposes, instead of battalions, contends for three ranks deployed, and the second line in columns, at quarter distance, ready to form squares when required: but both he and Jomini agree in the unprofitableness of fire from a third rank; in which they only maintain opinions that were long ago held by Folard, Saxe, and Lloyd.

Another system may be suggested, which would obviate many inconveniences under which the present labours. The present system of the infantry might be left, such as habit, founded on experience, has framed it; with the exception of arming a third rank with rifled fusils and spears, about ten feet six inches in length. The fusil, when not used, to be slung on the shoulder in the manner of riflemen; and the spear, with a spike, to fix in the ground; and a hook, about four and a half feet from the bottom, to serve for a rest in firing.* As light infantry now form nearly one-third of the foot in armies, this species of troops should perform all their duties, and be exercised accordingly. When scattered in front, their fire from a rest would be more destructive; the spear would give them more confidence and security against light cavalry. When called back into line, they would give it solidity; and in a charge, their spears, reaching beyond the bayonets of the first rank, would render it doubly formidable. Being drilled to form in front or rear, they would be the first rank, when the battalion forms square, to resist cavalry. In pursuits, they alone should be let loose upon the enemy. By their institution, every battalion, every detachment, would have its proportion of light infantry; intrenchments would be more obstinately defended, and breaches more easily stormed. If a rivulet were to be forded, their spears would sound for a passage on a whole line in a moment. On the outposts, three spears and two great-coats would form a tent. The idea is not new, for the Austrian militia in Hungary have a corps (Granitzer Schutzen) thus armed. Should the cuirassiers in the armies again resume the lance,—an event of some probability, since it is asserted that the Polish lancers of the guard of Napoleon, now in the Russian service, changed their small Ukrain horses for a larger breed about two years ago, with the in-

* As these troops would have no bayonet, they might be furnished with Pontoneer swords, and saws and hatchets; both instruments of great utility in securing posts, clearing obstacles, and opening roads, and a thousand other daily wants. It is not meant, that they should not have a drill of their own, and modes of formation independent of the battalion; but merely that, in giving or receiving charges in line or square, they should then constitute a third rank.

tention of being converted into cuirassier lancers,—it may be foreseen, that the spear will again be resumed in the infantry.

X. On the extensive subject of position, we can only give some particulars.

1. The best military positions cannot cover a state merely by being occupied and maintained.

2. Every position has its key or decisive point, as before observed: but this point is not difficult to find. In a scattered line, it is in the centre; in a contiguous line, it will be found on that point where the nearest connection lies with the base of operations.

3. When an army occupies a position upon a height, or any other ground fit for a field of battle, it is important to have the front and flanks most carefully reconnoitred and watched, to prevent the enemy gaining either extremity of the line by a secret movement.

4. But as it is admitted, that to employ strong corps for that purpose, causes a useless waste of force, attracts the attention of the enemy, and does not, after all, secure the army from surprise, it is preferable to place small posts of observation in all the sinuosities of the ground, with orders to communicate with each other and with the army, or the nearest intermediate corps. These two latter rules were demonstrated by the surprise and attack of the Prussian army at Hochkirchen, of Korsakoff at Zurich, and Murat at Tarutina; but especially on the first-mentioned occasion; for, next to the battle of Leuthen, no instance produces more ample proof of the terrible effects of an army being surprised and taken in flank. The whole mass of Daun's forces was actually upon both flanks before they were discovered.

5. On ground of difficult access, such as vineyards, inclosures, gardens, steep heights, &c. the defensive order of battle should be in lines deployed two deep, covered by swarms of skirmishers. But the corps destined for attacks, and the reserves, are best in columns, formed on their centres, in the manner above described (IX.); for the reserves, being destined to fall upon the enemy at the critical moment, must advance with resolution and rapidity, that is, in column. If, however, it be desired to awe the enemy by a greater display of forces, the reserve may be deployed until the moment of attack.

6. A superior army should never wait to be attacked, still less wholly deploy into line, if compelled by circumstances to remain in its post. In this case, no more troops should form line than are necessary to check the enemy. The remainder, formed into three or four heavy columns, should be placed ready to strike a decisive blow upon the most important point. A great army wholly deployed can no longer manœuvre with the same facility as columns; and to render troops not engaged immoveable, is repugnant to the best principles of tactics.

7. An army posted behind villages should cover the front with them, by occupying the inclosures, &c. with some battalions of infantry, and the outlets with cannon. The first line should be sufficiently near to sustain and be sustained by them, and also to provide the means of securing the evacuation of the place, in case the enemy should have gained so much ground on other points as to be able to mask them. Villages, being liable to be turned, should not be held by considerable corps of infantry, unless their topographical situation should constitute them the key of the position, as was the case at Vimiera. The battle of Blenheim deserves attention on account of the consequences produced by the neglect of the principles applicable to villages.

8. When an army occupies a position perpendicularly to a river, with a wing resting on the border, that wing should not be attacked, because, if the enemy changed front in mass towards the river, the attacking corps might be driven into it. On the contrary, if the onset is directed against the other wing with the principal mass of forces, that chance is in favour of the assailants; because the wing being turned, the whole line will be pressed towards the stream, and incur the risk of being destroyed. This would have been the case with Hiller's corps at Wagram, if a prompt retreat had not saved it. Similar would have been the fate of the united French armies at Talavera de la Reyna, had they persisted in an attack upon the Spaniards; and they acted with great judgment in directing their efforts solely towards Lord Wellington's left.

9. In the successful defence of a position, a repulsed attack should not be pursued, unless that attack had been decisive; because it might have been combined by the enemy for the purpose of drawing the defensive force out of its advantageous ground. An untimely pursuit by the Austrian right lost the battle of Prague; and by the Saxons that of Kesselsdorff; and again by the Austrian centre that of Jemappes.

10. Positions may, sometimes, be so arranged, that although they be scattered, they still possess the faculty of timely re-union. Several are indicated in Frederick's secret strategical instructions, and one occurs when he besieged Olmutz. Being greatly inferior to the enemy, who menaced him from several quarters, he posted a corps at Littau, while he remained in person with the covering army at Prosnitz; and in order to connect the two masses at will, a small corps occupied the hill of Hrad, between Namiest and Laskow, to serve as an intermediate point. Orders were given to the corps at Littau, in case of attack, to retreat towards him, and if a superior attack were made upon the covering army, he would retire towards the other; but if timely information were received, all were to unite in the position of Gross Jenitz.

11. As it is a maxim to operate against a weak part of the enemy's line, no position should be attacked upon its strongest point, as the Austrians did at Breslaw; but if the hostile position be prolonged by a detached corps, the principal effort should be directed against it; because, if that be defeated, the main body is turned, and thereby worsted.

12. Armies may sometimes be posted behind a ridge of hills with defensive points upon their summits. These should not be attacked without an exact knowledge of the position behind, and precau-

War.

tions to resist a counter movement. The events of Austerlitz and on the Katsbach prove the necessity of this precaution.

13. No position or disposition of attack should be made where the line is intersected perpendicularly by a difficult obstacle, such as a river or morass; because the enemy may act defensively on one side, and throw his whole mass on the other; as happened at Dresden, where the left wing of the allies was separated from the main body by the ravine of Plauen, and severely handled.

14. When an army remains immoveable in its position, both its flanks are liable to be turned. To obviate such manœuvres, others of a similar character should be opposed to them; as was done at Albuera. These counter manœuvres are not difficult to execute, because the army turning a flank moves upon the arc, while the opponent takes the chord; consequently he is enabled to move a greater mass in less time, even when both parties are equal in forces. Rosbach, Vimiera, and Salamanca, are decisive examples, where the enemy moved in open day (which it is both difficult and dangerous to do in the night), and thereby rendered the counter offensive both prompt and decisive.

15. There are positions which cannot be turned nor attacked obliquely. If the stratagem to draw the enemy out of them does not take effect, a parallel attack with the centre reinforced is likely to be the best adapted to such circumstances. The dispositions of Marlborough at Blenheim were of this class, and deserve the study of military men.

On Angles or Formation *en Potence.*

1. Between two armies equally capable of manœuvring, the defensive one may form an angle with advantage to secure a flank from attack; but to render this precaution efficacious, the angle alone is not sufficient, because its utility is only momentary; the mass, therefore, should change front in the same direction, and present a whole line to the enemy.

2. If the army be sufficiently strong to assume the offensive against the assailant, a change of front, which is merely defensive, should be followed as soon as the angle is formed and the enemy checked; by placing the line in columns of divisions to the flank, and prolonging the direction from the position first occupied to gain the hostile flank. Thus taken in front by the angle, and in flank and rear by the new direction, the enemy will be defeated. See Plate CXXI. fig. 6. A the army endeavouring to turn the left flank of B, which forms the angle C, and under the protection of this corps, prolongs its line in the direction EE, by means of which the extremity of the hostile flank is gained. A cannot well oppose the execution of this movement in the presence of the angle C, and of the line E, which, though it be in column, can form in an instant; hence A must fall back and change front also.

3. An angle to the front of the line or *potence*, such as the Austrians formed at Prague and Kollin, is not so serviceable as one thrown back to the rear; because the enemy can readily outflank its extremity from his position, while that extremity can be sustained but by slow degrees. Thus at Kollin, the Prussian cavalry turned it at the beginning of the action; and at Eylau, Benningsen repulsed the corps of Davoust on his left, and Ney on his right.

4. If a defensive position has an angle to the rear, the front will be weakened in proportion as that angle becomes more acute: but, if there be a considerable interval on the summit, where the two lines should meet, the danger will be still greater; for if the enemy can establish himself on the point A, it is clear that the two wings, A C and A B, will be enfiladed and forced to retreat; if not rolled up in confusion by an actual charge on either or both of these extremities: this caused the defeat of the Austrians at Prague, and of the Prussians at Breslaw. (Plate CXXI. fig. 7.)

5. If two allied armies or great corps take up positions, forming a re-entering angle with a space between them, and some considerable obstacle masks that space, they expose themselves to be attacked and defeated separately: this danger increases with the increase of the distance between them. The corps A D being separated from B E, by a wood, lake, or other considerable obstacle, at G; the enemy F H, being covered by that obstacle, may attack and defeat one before the other can arrive to sustain it. (Fig. 8.) This principle results from the maxims of interior against exterior lines of operations. Such positions as these were occupied by Prince Henry and Hulsen, at Freyberg and Katzenhausern, with the Tharand forest, and what was worse (at the distance of more than six leagues), with the Mulde between them. Yet the army of the empire, superior in force, remained three months before them, until Prince Henry moved and defeated it at Freyberg.

Oblique Attack. General Observations.

1. To insure the success of an attack, properly combined and reinforced on the essential point, it is necessary to refuse the weaker wing. This precaution is obvious, not only for the purpose of keeping a weaker part out of reach, but also because reinforcements are readily drawn from it, to the point where the effort is making. Thus, instead of exposing it to be repulsed by superior forces, there is a real advantage in keeping it reserved to secure the victory. Leuthen affords a proof of the wisdom of such a disposition; Kollin and Jœgerndorff of the consequence, when disregarded.

2. If it be admitted, that the most advantageous attacks are those which emanate from a concentrated effort, upon an extremity of the hostile line; it becomes indispensable to gain that extremity, by measures which mask the movement. For, by neglecting this precaution, the enemy may follow the march of the columns in their endeavours to turn him; present constantly a front, or even anticipate, and take them in flank, as happened at Rosbach.

3. The march may be concealed by the darkness of the night, by the conformation of the ground, or by means of a false attack on the front of the enemy. The two last mentioned are to be preferred; because night marches are uncertain and even dangerous, slower, and always more irregular than those by day. For this purpose, it is not necessary to march by lines, if the movement be masked by an attack of the advanced guard, while the mass advances towards the extremity desired, in columns of battalions at half

distances. This will render it difficult to be discovered by the enemy, in time to be counteracted.

4. In order to molest a greater space of front, instead of an advanced guard making a regular attack, it is preferable to employ a corps of light troops, formed in parties; having points for re-assembling light cavalry and some artillery to sustain them. This method is sure to distract the enemy's attention, and keep his whole line in check.

An oblique attack, according to Guibert and the *Journal Topographique*, is *a disposition by which a part, or the choice of the forces, are advanced towards the enemy, and the other kept out of his reach.* This definition is not quite correct, as Plate CXXI. figs. 9, 10, 11, and 12 demonstrate. An army may be out of reach of the enemy, and therefore refused in a line nearly parallel, and strongly reinforced on a wing, without being oblique. (Fig. 9.) It may also be in an inclined line on the head of the attacks, and form a positive diagonal, without being reinforced (fig. 10); or perpendicular upon a flank, as at Kunersdorff, with a wing reinforced (fig. 11); or horizontal upon the head of the columns without being oblique. (Fig. 12.) There are several modifications of these four orders (among others fig. 11); as, for example, a perpendicular angle to the front, as formed by the Austrians at Prague, Kollin, and Hochkirchen (Plate CXXI. fig. 13); the angle A C being perpendicular to the army D E, reinforces the right wing of the line A B without being oblique: so also an angle to the rear would reinforce the line without obliquity.

A parallel line, considerably reinforced upon the most important point, is no doubt good, and even very generally applicable; for it is conformable to the principle which forms the basis of all operations: but it has several inconveniences. The weak part of the line being near the enemy, may be engaged contrary to the intention, and be defeated; which event would balance and arrest the advantages gained on the other wing; as happened to both armies at Wagram. The reinforced wing having defeated its opponent, cannot take it in flank and rear without a considerable movement, which would separate it from the other, if already engaged. But admitting the weaker wing not to be engaged, the other cannot even then turn the flank without drawing it circularly along the hostile front, which the enemy must necessarily anticipate by being on the chord of the movement; and consequently give him the advantage of the offensive by reaching the decisive point first with the mass of his forces.

With the oblique order of Frederick, as applied at Leuthen, the effect is quite different; the extremity of the wing attacked is not only overpowered by a whole line, but the end of that wing is constantly outflanked, and the line turned, without manœuvre, or prolongation of direction, simply by a direct advance of the oblique line. The distance of the divisions which are not intended for the principal attack, places them out of the danger of being engaged by a superior force, and yet sustains the wing in action. These effects of the open oblique attack, although known, cannot be too often presented to the reflections of military men. They offer, besides, another advantage still more decisive, in bringing the half of the army constantly into action against the extremity, probably of only two brigades, of the hostile army, which has no counter manœuvre to stop its progress. What troops can stand against such odds, when besides they are constantly outflanked and taken in reverse? Is it possible that confusion and dismay should not follow in a whole line, whose flank is overthrown, and menaced with total destruction, by the progressive advance in a direction upon the rear?

Yet such must be the infallible result of an oblique attack when once it has reached the flank of the opponent undiscovered; as indicated in the preceding maxims; and when the lines are rapidly formed, according to the method of Frederick; as will be seen in the observations on marches. Plate CXXI. fig. 14, demonstrates the mechanism more clearly. The left wing, B C, of the army, A C, will receive the fire of the second brigade of the army, D K L, whilst the first brigade, or extreme right, formed in column of divisions, will turn it and decide the first attack with rapidity. The second brigade, in the oblique direction of its march, will soon be seconded by the third; and when that has passed the extremity, which must constantly recoil before a contiguous front, the fourth brigade opens its fire; and in this manner, supposing the army, D F, K L, arrived at the dotted line, H I, the whole will have been engaged in succession with a fourth or a third of the enemy's line, the battalions of which, being crushed one after another, will be nearly surrounded.

This demonstration is sufficient to show the great advantage of an open oblique order of attack. It is called open, because the disposition, such as that of Leuthen, was nearly at right angles with the line of the Austrians, and different in every respect from a parallel order. All these advantages are equally applicable to masses concentrated upon the extremity, which it is intended to crush. The army A B, fig. 15, instead of forming two lines, as in the former figure, may draw up the first line only, and keep the second in columns at half distances behind the right, centre, and left, prepared to manœuvre or strike the decisive blow. These columns will be more moveable, and not being intended for the first attack, they will nevertheless cover it against counter-movements of the enemy. The battle of Salamanca offers a memorable lesson of this description, where the troops were concealed by the ground, and then suddenly brought in mass upon the enemy's left wing. That of the Katsbach, almost the counter part, was equally grounded upon these principles; both, however, with the difference, that the lead of the manœuvres was on the side of the adversary. Jomini, habituated to the lively national character of France, lays too much stress on the value of the lead in manœuvres, and therefore does not fully appreciate the powers of well conducted counter-manœuvres, which the cool firmness of British and German soldiers can develope.

The battle of Leuthen furnishes another maxim equally important; namely, that an army with the flank resting upon an obstacle, such as the great

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pond of Gohlau, which covered the angle of Nadasti, may still be outflanked by an oblique attack. For this purpose, it is only necessary to mask the first brigade of the enemy by the nearest of the attacking corps, and move obliquely with the next, so as to press the principal effort upon the second. For the line being broken, the obstacle is no longer of any use; and the masked brigade is even in danger of being taken if not promptly withdrawn. But the manœuvre is not so advantageous as when the flank is ill supported and easily turned.

Of Marches.

Marches in columns to the front, flank, or rear, which must be followed by deployment or echellon formations, are useful as parts of elementary tactics; but never safely applicable near the enemy on a great scale, if they are at all complicated in the construction of the columns, or in the nature of the ground. Guibert devoted several volumes to their mechanism; but Tempelhoff alone has described the nature of Frederick's columns, by means of which his dispositions were executed with so much simplicity and precision. Although the present system of moving by corps has, in a great measure, superseded the old method of organization by lines, and consequently rendered the march manœuvres, which triumphed at Rosbach, Leuthen, and Zorndorff, less applicable; they are still the best for such corps as are obliged to manœuvre in the presence of the enemy, whether it be to engage in front or to turn his flank.

On examining the mechanism of his columns at Kollin, Leuthen, &c., it will be perceived, that his army having broken into open columns, each line forming one by a mere wheel of divisions, right or left in front, by this method the army could,

1. Execute all the movements united without danger of being attacked in detail; because the columns of lines were at no further distance than was required for actual engagement.

2. The enemy could neither cut them off, nor penetrate between them.

3. In taking the direction of the intended line, the army, when moved to the ground, is formed in a few minntes,—that is, in the space of time required for the word of command to pass down the column to wheel into line. In this method, the only precaution required was to send an advanced guard to protect the march, and at the same time to keep the enemy in suspense.

4. As the army requires only two or three hundred paces between the columns, and the divisions no more than their respective distances to form into two lines, the manœuvre is easily executed with precision.

5. The army having reached the flank of the enemy by concealing the movement, as before noticed, and wheeling into line, will not allow the enemy time to form an angle, or to change front; consequently, he will be overpowered in succession along his line.

6. To conclude, if two columns, of the length of the line of battle, are not immediately desired, or the ground requires a modification, four columns may be formed, by doubling up the lines, or by marching by wings, without increasing the difficulty of forming. The four columns being constructed of the two lines doubled, when arrived near the point where they are to form, the second and fourth halt until the first and third have proceeded so far as to disengage from each other. While halted, they protect the march of the others, and when cleared by them, they follow in their rear, and thus are prepared to wheel into line with them.

If the columns are formed by wings, they will again fall into two lines by a simple change of direction, executed by all the heads of columns of each line at the same time to the right or left, and then leading into the rear of the preceding. But this transition of columns of wings into columns of line should take place at some distance from the enemy. At Leuthen, this manœuvre introduced the battle: Plate CXXII. fig. 16, A, the advanced guard masking the march of the army in four columns; B B B B, the heads of the four columns forming the first line; and C C C C, the heads of the second line (now in rear of the first), all changing direction by a wheel to the right at the same instant, and consequently forming two open columns ready to wheel into line. The advance meantime either halts in position to alarm the enemy on another point, or continues to open the march by preceding and covering it.

It is, however, evident that these kinds of marches must be made on open ground; for in countries deeply intersected, great movements are impracticable; and it thus becomes necessary to arrive by the openings which are known, and engage more or less in columns. By Guibert's and the regulation systems the army being broken into several columns, they move with their heads often out of sight of each other at the distance of more than a mile, and yet they are expected to keep their alignments and relative distances. When ordered to form, they either close and deploy, or march by echellons to fit into an exact alignment. All this is evidently impossible before the enemy, who must discover the tedious manœuvre, and have time to act as he pleases, while the numerous errors are rectifying; and if the centre divisions should be chosen for the points of deployment, half the columns must turn their backs upon his fire to perform it! Frederick, during the whole Seven Years' War, attempted these movements only twice; first in a combination with Bevern to attack Loudohn, which failed by the premature arrival of one column; and, secondly, at Torgau, which, as far as that manœuvre was concerned, failed also; for Zieten's column came too late, and was isolated. At Minden the French manœuvred in the same manner, and were a great part of the night and the next morning employed in rectifying the errors, which gave Prince Ferdinand time to arrive. It is true, he moved likewise in columns, but he had previously sent all the generals to reconnoitre their routes and points of formation, and cut openings and fixed marks to insure the exact direction. Such precautions surpass even the underhand tricks to help the manœuvres in a camp of instruction; and the very precautions prove the impossibility of applying them in ordinary cases. During the Revolutionary wars of France, all the Belligerents met with fail-

ures from vain endeavours to apply them; notwithstanding that the new organization of corps and the use of swarms of skirmishers greatly facilitated their execution.

Lehwald's manœuvre at Jœgerndorff is worthy of notice, as particularly applicable in intersected ground. His infantry advanced in a double column from the centre, and formed to right and left without risk of confusion; the cavalry moving at some distance, easily took up the alignment.

The order of march on Frederick's system must, however, be considered only as a manœuvre, and not be applied to marches in great operations.

As this order of march is best calculated for attacks against lines, so is it also upon columns in march. An attack upon an army while on the march is advantageous, for the same reasons as an attack upon an extremity of a line; because the army attacked on the heads of its columns is precisely in the same situation, relatively to the enemy, as one assailed in flank. The battle of Rosbach furnishes an illustration. AB, Plate CXXII. fig. 17, represents the army of the King, CD that of the French. Supposing them both in line, CD would still be attacked perpendicularly, and outflanked on one of its wings, exactly as it was on the head of its columns. The advantage of both these manœuvres lies in the necessity to which the enemy is reduced of bringing his battalions in succession to the front, while the opponent, acting with vigour, defeats them, one after another, by the superior pressure of his mass, provided its march be onward in an appropriate direction. Horizontally, if the column moves perpendicularly, and perpendicularly, if the march is horizontal. The object for producing, as nearly as possible, an opposite direction, is to present a whole line to a head of a column, or to an extremity of a line; because, if both moved in a direction to meet with the heads of their columns, both would be obliged to deploy, and a parallel order would be the consequence, without tactical advantage to either army. Fig. 18, the columns AB meeting those of the enemy CD in the same order, both fearing to be attacked, will immediately deploy; AB will therefore form the line FG, and CD the line HI, which gives no advantage to either party.

The battle of Rosbach offers a further illustration. As an angle must necessarily be formed when the heads of columns are attacked, to check the first efforts of the enemy, the advanced guard or leading brigade should deploy, while the rest of the army should take a new direction of march clear of the enemy's flank, in order to protect the retreat of the advance already engaged, and to gain a station for acting offensively. See fig. 19. If the advanced guard or leading brigades AB of the columns HI be attacked, a deployment must take place according to the direction of the attack CD. This manœuvre having checked the enemy FG, the army in the rear being thus momentarily protected, should immediately change direction exteriorly, by filing the divisions into a new alignment, IL; or by altering the direction of the columns in a similar manner, so as to produce a prolongation beyond the enemy's flank, KK. It is, however, clear, that if the columns are left in front, the operation is according to rule; but if the right be in front, a direction to the left would present the reverse flanks to the enemy. There would be no time for a countermarch, and still less for wheeling up in succession. It therefore appears that the columns should change the pivots of divisions, and wheel to the right into line; for though this manœuvre would be against the letter of the regulations, no disorder would ensue, and it is actually practised, at least by cavalry, in some of the continental armies. There is no want of proofs of the occasional necessity of this manœuvre in every campaign; but the battle of Laswaree will suffice for an illustration. The British infantry advanced in a single column by the right, and after crossing the Mahnus Nye, a deep sunken rivulet, found itself opposite the enemy's right. To have prolonged the movement, was to produce a parallel order of battle; advantage was therefore taken of a ravine which led to the hostile right flank, and could conceal the movement. The head of the column, therefore, turned to the left, and gained the flank; but when ordered to wheel into line, the pivots being reversed, some of the Sepoy troops adhering to the letter of the rules and regulations, wheeled with their backs to the enemy.

This method of converting a probable defeat into an offensive movement and oblique attack, will probably intimidate the enemy, and check his pursuit of AB, from the moment he perceives the menaced attack against his own flank. As a manœuvre it is also more rapid and simple than a change of front which would only tend to a parallel formation. Although the existing modifications in the structure of armies, as already observed, renders this kind of attack more rare, and the organization by corps and divisions is advantageous to prevent them, it is nevertheless true, that the Prussians lost the battle of Auerstadt, and the French were placed in the most critical situations at Marengo, Eylau, and Lutzen, because they were attacked on the march before they expected a general action.

Principles of Dispositions at the Battle of Waterloo.

The battle of Waterloo, unquestionably the most decisive event of the late awful contest, offers so many instructive circumstances, and so much matter for deep meditation, in the position and manœuvres, and in the exhibition of the soundest maxims of war, that it may be considered as a general illustration of the advanced state of the art of war at the present period. Without entering into details, the minutiæ of which are apt to confuse, we shall content ourselves with merely pointing out the principal dispositive features which it displays. As there are many plans more or less correct, and the ground is generally known, the remarks we are about to offer will be readily understood by those who have any elementary knowledge of war. After Blucher's retreat from Ligny, and the Duke of Wellington had fallen back from Quatre Bras, he occupied the position of Mont St Jean, determined to risk a battle with the forces he could collect on that point. Exclusive of the Prussians, whose severe loss in killed, wounded, and stragglers, could not immediately be reorganized or replaced, but by the expected

arrival of the corps of Bulow, the Anglo-Netherland army consisted of about 81 battalions and 87 squadrons; which, with the artillery, may have amounted to 66,700 men. Of these, upwards of 30 battalions and as many squadrons had never been in action. This mass of forces was posted with the centre diagonally across and in front of the forking of the two causeways from Brussels to Charleroy and to Nivelles; the right centre behind the chateau of Goumont, and the left considerably refused, passed in rear of La Haie Sainte, along the cross road in the direction of Ohain. Behind the right centre, Lord Hill placed his corps, *en potence*, in columns, prepared to manœuvre to his right, on the small plain of Braine la Leud; or to his left, to sustain the centre. In and about Braine la Leud was a Netherland division, with the right thrown forward, and covered by the rivulet Hain, and leaving the small plain open; a kind of gorge to tempt the enemy between the two sides of the re-entering angle of the right wing. The Prussians were expected to debouche through the woods of Lasne towards Planchenois, which would form the left into another gorge, or re-entering angle. Thus the position formed a kind of open W (BB, Plate CXXII. AAA. BB), with the chateau of Goumont at the summit of the salient angle, covered by a plantation of wood and inclosures, occupied by six or eight battalions; so that the enemy could not enfilade from behind that plantation, either of the faces of the centre, nor approach on either of the causeways which passed through the centre, without presenting his flank. Besides this point, La Haie Sainte, a stone farm close to the chaussé of Charleroy, and further on the left, the farm of Papelotte and chateau of Frichermont were occupied; the whole front offered a gentle slope towards the enemy, and in the rear the cavalry was distributed in brigades, each in two lines, covered by the rising ground; and the artillery, all the field-pieces of which were nine-pounders or twelves, formed a line of almost contiguous batteries along the front, interspersed with howitzers and rockets.

By the returns found after the battle, it appears that the enemy had debouched from Charleroy with 122,000 men,* exclusive of the reinforcements that joined after the 15th of June. Of these he produced on the field of battle, about 80,000 men, formed in concentrated masses on both sides of the chaussé of Charleroy, and gradually advancing the right parallel to the British left (CCCC); but as he was jealous of the woods on the right, he formed an angle to the rear, and kept his reserves far back. He had made a demonstration with a corps of cavalry beyond the British right towards Hal, where he found the corps of General Colville, and Prince Frederick of Orange, with two divisions posted at Tubise, Clabbeck, and Braine le Chateau, to cover that avenue to Brussels: another corps, 42,000 strong, under Grouchy, was detached to his right upon Wavre, to turn the allies, pursue, or arrest the Prussians, and prevent the timely junction of Bulow. Thus the dispositions of both the commanders were combined with consummate ability; Napoleon operating on the system of throwing two-thirds of his masses alternately on either side, and the allies, in combining manœuvres, to bring a superior mass on the decisive point. On the field, however, the problem was difficult to solve. The communication with France was open only by the roads of Charleroy and Nivelles; hence the enemy could not quit them in the attack; nor could he gain Brussels by any other avenue than that of Waterloo: therefore, to possess the chateau of Goumont, without which he could not arrive at the position, was the natural object of the attack. As this was sustained by the mass of the allied army, and could not be enfiladed, his attacks failed. All those directed on the road of Charleroy to the left centre, were necessarily oblique, and exposed to the fire in flank before they could reach their opponents. To have risked a general onset of all his masses, before the British were thinned and exhausted, he knew, under the circumstances of the moment, to be too hazardous. The plain of Braine la Leud appeared open. He could arrive by it; but that very circumstance proved that the enemy was prepared on that side. To have turned the force thither would, in the first place, have caused the loss of the communication by Charleroy; and next, facilitated the junction of the Prussians; and, besides, the corps on the other side of the Hain flanked the advance, and could, in a short time, be sustained by the two divisions in its rear, and which he knew to be at hand. He would, therefore, have been placed between two fires, and have lost his point of retreat upon Charleroy; and the road by Nivelles might, meantime, be cut off by the troops left behind at Mons. Again, if he threw his masses towards the left, he only went to meet the Prussians, and left the British masters of the road of Nivelles; and possibly, if he advanced far, of that of Charleroy. He entangled himself in woods and defiles, where his superior cavalry could not act. The character of his opponent bespoke immediate offensive movements from the moment his right would be at liberty; therefore the chances were again in favour of the enemy; yet this was the only advantageous side, because it brought him nearer Grouchy; and in case of defeat, he could take a new line of retreat by Namur. He, however, preferred the experiment which the enthusiastic valour of his troops might enable him to make; and this committed him so deeply, that, when at length the Prussians appeared, a retreat was no longer possible.

These observations disprove the ignorant assertion, that little skill was displayed on either side. The Generals and the soldiers equally did their duty: the veteran Blucher behaved with just prudence, in keeping so long back from the dangerous manœuvre which was assigned him; and when he saw the hostile cavalry destroyed, he acted with vigour and skill. As for Grouchy, who wasted his time

* The return was dated the 13th, according to the assertion of a Prussian officer of the staff. The whole force brought over the frontier must, therefore, have amounted to nearly 150,000 men.

in forcing the position of Wavre across the Dyle, everywhere fordable, his manœuvres show, that he felt the danger of his movement, and he wisely remained on the banks. Much might be added upon the judgment which posted the corps at Wavre and another at Hal; on the several lines of retreat which the allies could take in case of defeat; on the dispositions of the artillery; the squares and lines formed and reduced repeatedly; the disposition and effect of the charges of cavalry; the counter offensive of the Prussians; the general charge to the front, and fate of the enemy's squares: but sufficient is advanced to excite to the study of a battle, where three of the greatest commanders, and the best manœuvring armies in Europe, gloriously struggled for victory; and, let it be added, notwithstanding the assertions to the contrary,—where none committed a positive fault; and where Napoleon, in particular, who has been condemned by some of his own partisans, operated with all the skill and vigour which the circumstances of the moment allowed.

Of Retreats.

This unpleasant operation in war requires as great a display of skill and firmness as any. The Austrians have often conducted their's with sagacity, and it is perhaps owing to the preserving spirit of their retreats, that after twenty unfortunate campaigns, the monarchy was as formidable as in the commencement. Their Generals are not then controlled by cabinet orders, and, therefore, always operate with precision. Among the retreats which deserve the study of the soldier, are that of Schulemburgh, with the Saxons; the Duke of York's out of Belgium; the two retreats of the Archduke Charles; that of Moreau from Bavaria to the Rhine; the Russian retreat upon Moscow and Tula; and, lastly, the fine movement of Prince Eugene Beauharnois, in Italy.

In the choice of a position, it is not sufficient to have a strong front and secure flanks; the means of retreating must also be considered in case of defeat. Lloyd, in his *Reflections on the battle of Kollin*, observes, that a defeated army retires with greater facility by dividing itself into as many corps as the nature of the country will allow; because, 1st, if the enemy forms an equal number of divisions, he cannot operate vigorously upon any, and the retiring army having the facility of *reuniting*, may totally defeat one of the hostile corps; 2d, if the enemy operates *en masse*, it can be only towards one, and the others fall back unmolested: that division, however, covered by a strong rear guard, avoids serious actions, and having the faculty of moving more rapidly, because it is less numerous, can escape likewise without great loss. Bulow, taking up this question mathematically, advances the opinion that the columns should move outwards, or eccentrically, from a point towards the periphery; but Jomini combats both so far victoriously. He observes, that Lloyd admits that the division of the pursuing forces exposes them to defeat; why, then, recommend such a manœuvre to a retreating army, which must be already inferior to the enemy? He quotes the fine concentric retreat of the Archduke Charles, and might have added the Russian, and both Lord Wellington's. But in examining the mechanism of these movements, it appears that none of them were the consequence of a defeat, and especially such defeats as the modern system of attack inflicts; they were merely armies manœuvring back towards their base upon their own lines of operations, watching a favourable opportunity to resume the offensive; or retreats after battles where both parties had claims to the victory, as Benningsen's after Eylau, and Kutusoff's after Borodino. The difference between Lloyd and Jomini is merely in words; for the former points out the facility of uniting two corps, which, if he meant the eccentricity applied by Bulow, would be impossible.

But an army completely defeated is no longer in the hands of the general, whether he be the Duke of Brunswick or Napoleon. A check, such as the Austrians suffered at Fleurus, and the Allies at Lutzen, Bautzen, and Dresden, does not prevent the commander from executing the best measures that circumstances will allow. Thus, in the three former, the armies retired in mass; in the latter, they divided into several columns, and thereby not only covered themselves by the mountains of Bohemia, but also applied Lloyd's maxim, in uniting two corps to destroy one of the pursuers at Kulm. Hence, circumstances must govern the measure; and if, after a real defeat, a broad river, chain of mountains, or range of fortresses, can be gained in two or three marches, the division of a routed army may be applied as a safe rule.

A retiring army is not always obliged to fall back upon its own frontier; it may sometimes change the direction of its operations, as Frederick did after the siege of Olmutz in 1758; when, instead of returning into Silesia, he changed his line, and marched into Bohemia. This measure was also proposed to Napoleon before the battle of Leipsig. He was advised to approach the Elbe, call in the corps of St Cyr from Dresden, cross the river about Wittenberg, and descend by the right bank towards Magdeburg. The Prussian and Northern armies, being on the left of the Elbe, could not have prevented the destruction of Berlin, Potsdam, and Brandenburg. And from Magdeburg, reinforced with its vast garrison, and connected with the Danes and the corps of Davoust at Hamburg, he could have operated by a new line, having his communications open by Wesel, Cassel, and all the fortresses of Holland; the sterile country to which the allies must have followed him could not have subsisted their vast cavalry; and the sandy roads would hardly have allowed sufficient transport of provision to maintain the troops. There were, however, many, and probably superior reasons, which made him reject the proposal.

Pursuits.

If the art of war consists in applying the superior force of a mass upon a weak point of the enemy, it follows that a defeated army should be pursued with the utmost vivacity. Never delay till to-morrow, is an ancient military maxim, applicable especially in pursuit; for the strength of an army consists in its organization, in the unity resulting from the connection of all its parts with the main-spring which makes it move. After a defeat, this unity no longer exists. The harmony between the head, which combines, and the body, which executes, is broken; their connection is suspended, often destroyed. To

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pursue and attack is to march to a certain triumph. All the late campaigns offer signal examples of this truth. Generals of mediocrity often neglect this maxim, and their victories are scarcely more than a forcible removal of troops. The direction of the pursuit, though guided by circumstances, should always, however, aim at gaining the hostile line of communications, and cutting off the enemy from his base; because, by so doing, he may be thrown upon such obstacles as to force him to surrender.

Sieges.

Sieges, according to Lloyd, should never be undertaken but with the following views: 1st, When fortresses are situate upon the passages which lead to the enemy, so as to render it impossible to penetrate without capturing them. 2d, When they intercept the communications, and the country is unable to furnish the necessary subsistence. 3d, When they are wanted to cover magazines formed in the country, and thereby to facilitate the operations. 4th, When the enemy has considerable depots within the fortress, of which he is absolutely in want. 5th, When the capture of a fortress produces the conquest of a considersble tract of country, and enables the besieger to winter in that vicinity. To these may be added, 6th, The recapture of a fortress essential in the defence of a frontier.

Covering Sieges.

1. As victory is best secured by taking the lead in an operation, an army covering a siege should never wait to be attacked by the enemy, but endeavour to anticipate him; for, by defeating the forces which aim at raising the siege, the place is sure to fall.

2. If the enemy approach the covering army with an imposing mass, the siege should be raised, all the forces united, and an attack in force directed against him.

3. When the relieving army is defeated, the siege should be resumed, while the pursuit continues, and the enemy is not in a condition to return before the capture of the place.

4. When an army besieges a place, in consequence of offensive movements and anterior success, the covering army should not remain in a position near the place, but drive the enemy as far as possible forward; for the relieving army will find the difficulty of raising the siege, increased with the distance it is removed from the place: but, if at length that army should arrive so near as to furnish a probability of raising the siege, the besieging corps should then rapidly join the covering army, and make a united effort to defeat it.

Concluding Remarks on Innovations and Improvements.

Among the late innovations in war three are of immense influence; but before they can be considered as permanent improvements, they will require to be subjected to some regulations. The first of these is the Conscription System; a salutary measure under proper restrictions; but a scourge, if carried beyond the principle of defence. The next is that of Requisitions; which requires to be placed under the control of public law. The third is the formation of a Militia, or Landwehr. This measure, incontestibly proved to be efficient, will always be resorted to in moments of real danger: and it is one calculated to bridle the projects of ambition, because it makes every state strong in defence, but not therefore strong in aggression.

In examining the new inventions which may become instruments of moment in the science of war, that of Vessels impelled by Steam will probably figure as the most important among maritime nations; whose coasts, rivers, and harbours, will probably be assailed and defended by them. The terrific Rockets may in time acquire a precision of direction equal to that of shells and carcasses. They are, in their present state, an excellent substitute for horse artillery, particularly in pursuits, vanguards, and false attacks. At the battle of Leipsig, a British battery of rockets compelled a column of four battalions to surrender on the first fire.*

The present method of forming divisions with artillery, a proportion of light cavalry, and light infantry, commissariat and staff, approaches so nearly to the Roman Legion, and is, in reality, so advantageous, that it may be foreseen, should one great continental state permanently model its army upon that principle, the others will immediately adopt it. Should the heavy-armed cavalry or cuirassiers resume the Lance, the infantry would soon be obliged, as before observed, to be partly armed with a similar weapon. Field Fortification has been too much neglected, and the troops are not sufficiently provided with implements for that purpose; but as the influence of militia systems will bring large bodies of troops together, in a state of inferior discipline to veterans, field works will recover their proper estimation.

It is not the solid immoveable system of Daun that is here in view, but merely such works as can be completed in a few hours; provided a greater quantity of light implements, as hatchets, handsaws, pick-axes, and shovels, be furnished the troops, and the proportion of battalion pioneers be augmented and rendered more respectable. Rogniat extols the advantages which the French army derived from this practice being introduced among the artillery sappers and miners under his orders; each of whom carried an implement of this kind during the campaign of 1813. It was by their means that the *Palankas*† were so speedily constructed before Dresden, upon which the formidable artillery of the allies scarce made an impression. This sort of field work is unquestionably of great importance where the materials can be procured; as appeared again in 1814 at Tournay, in the fruitless attack which, owing to its application by the Saxon engineers, the French, under Maison, made upon that place. The *Spanish* Redoubts, which the same ingenious officer recommends, appear likewise to possess great advantages; because they can be raised in a few hours, and are there-

War.

* Of this fact, the author was assured, by the late General Bulow, who stated that he rode up alone to receive their submission.

† So named from their Turkish origin.—Redoubts fenced with trunks of trees closely planted and pierced for musketry.

WAR. PLATE CXXI.

Fig. 1.

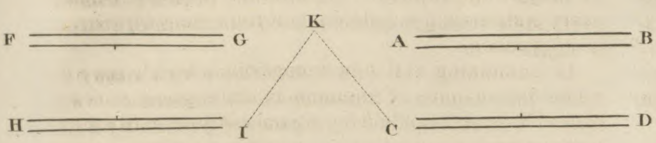


Fig. 3.

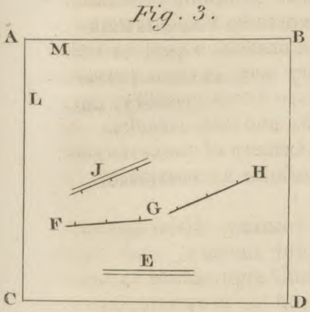


Fig. 2.

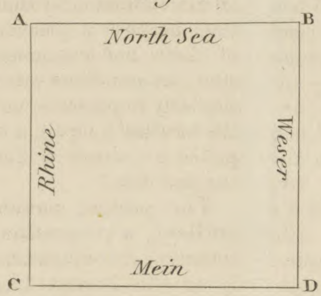
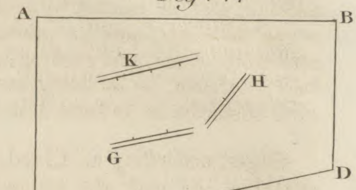


Fig. 4.



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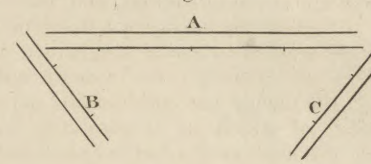


Fig. 6.

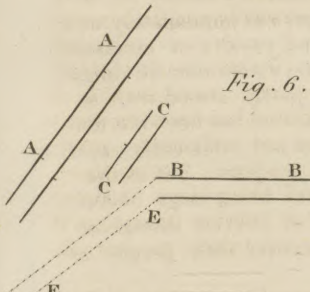


Fig. 7.

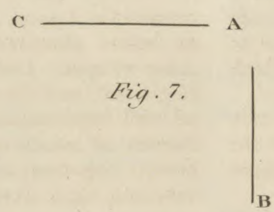


Fig. 8.

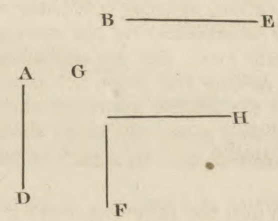


Fig. 9.

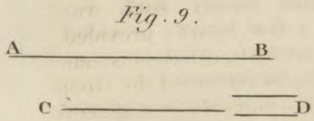


Fig. 10.

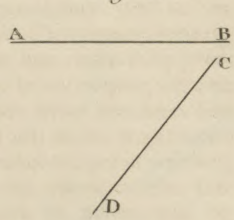


Fig. 11.

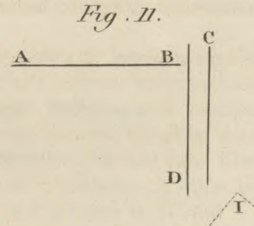


Fig. 12.

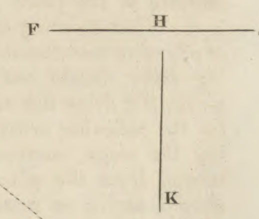


Fig. 13.

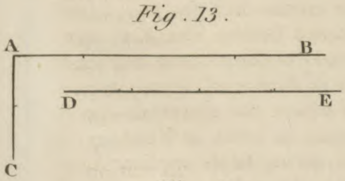


Fig. 14.

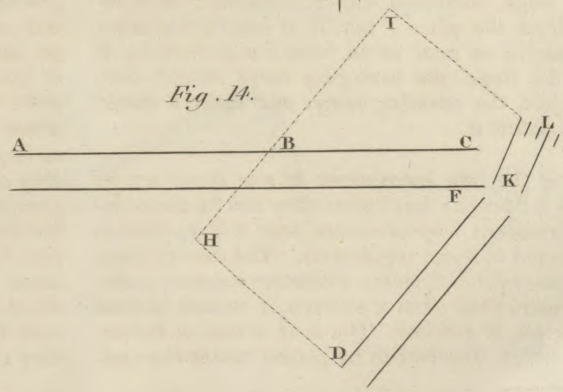
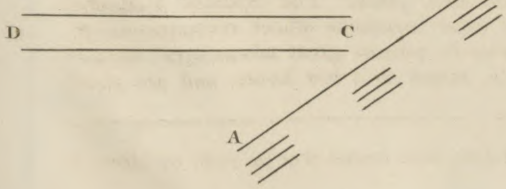


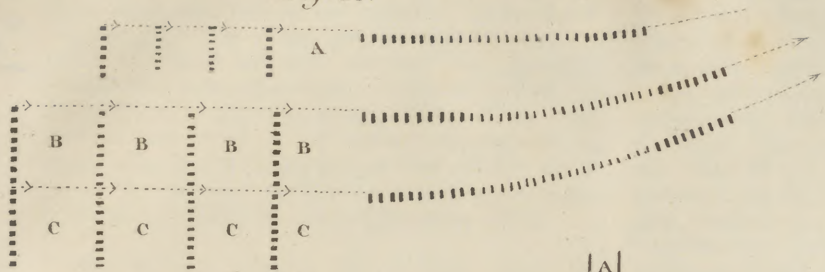
Fig. 15.



Published by A. Constable & C.º Edin.r 1824.

W. Archibald sculp.t

Fig. 16.



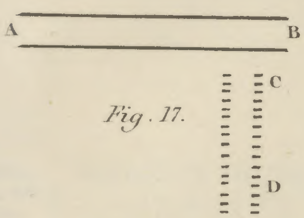


Fig. 17.

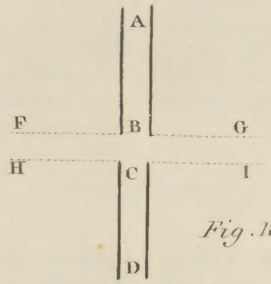


Fig. 18.

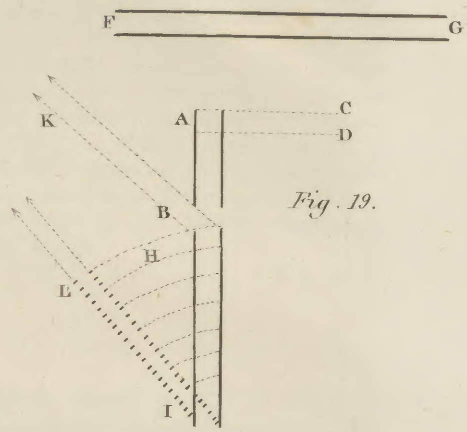
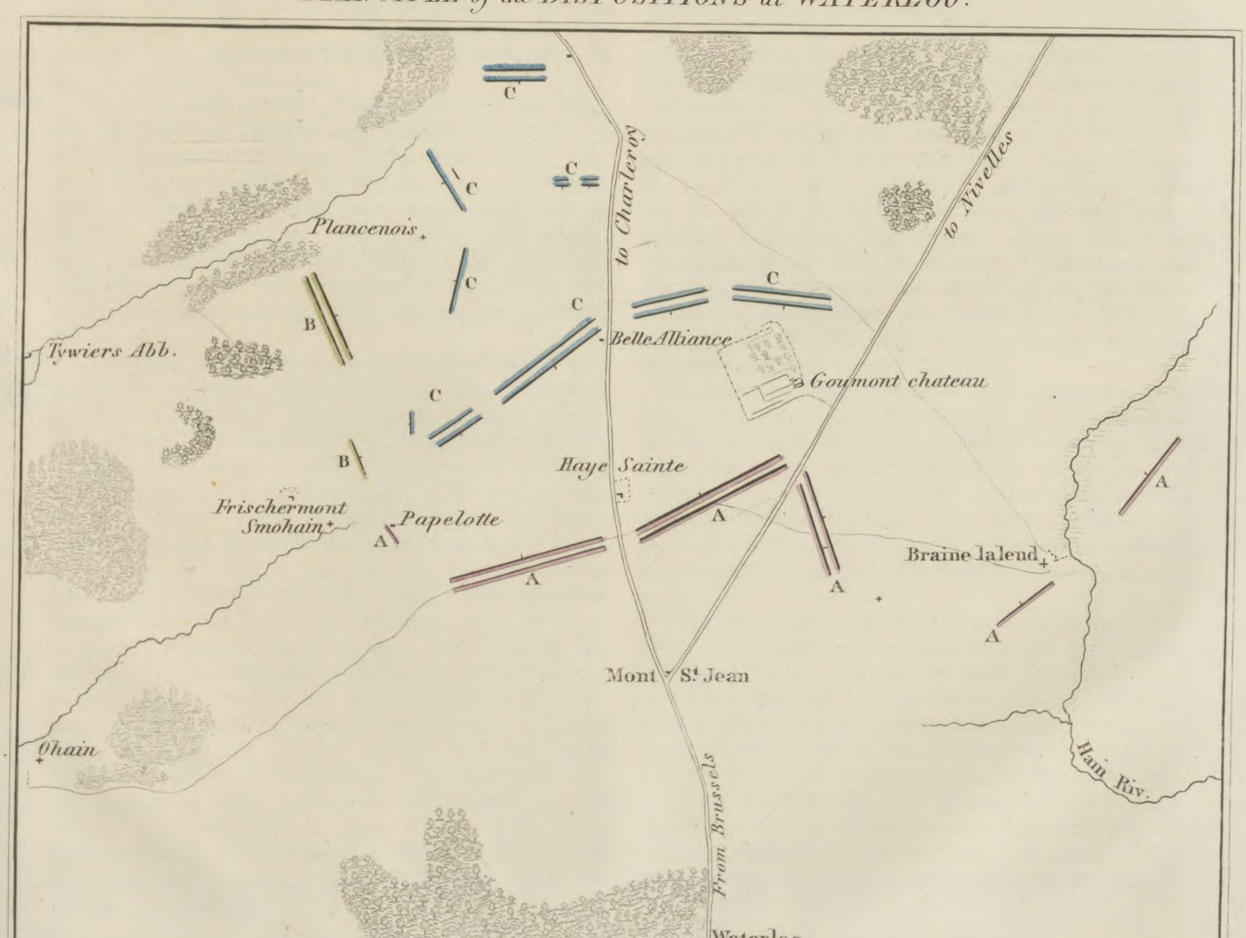


Fig. 19.

PRINCIPLE of the DISPOSITIONS at WATERLOO.



W. Archibald sculp.

Published by A. Constable & Co. Edinr. 1824.

fore applicable in a defensive position, if a single night intervenes before the attack. It is somewhat singular, that in the systems of permanent defence, it should not have occurred that positions, intended for intrenched camps, might be pitched upon; and that by planting, along the lines of the *tracé*, rows of such trees as will thrive close together, a cheap, simple, and strong preparatory defence might be raised; which, on the breaking out of a war, might easily be completed by the neighbouring militia.

See Guibert, *Œuvres &c.*—Jomini, *Traité de Grande Tactique. Guerres de la Revolution.*—Lloyd, *History of the Seven Years' War.*—Tempelhoff, *Geschichte des Sieben Järigen Kriegs.*—Frederic, *Histoire de Mon Temps. Instructions à ses Generaux. Instructions Secrettes. Art de la Guerre de Main de Maitre.*—Rogniat, *Considerations sur l'Art de la Guerre.*—*Œuvres du General* Warnery.—Venturini, *Angewante Taktik. Die Bellona. Die Minerva.*—Scharnhorst, *Militairisches Taschenbuch. Militairisches Journal. Nähere Beleuchtung des Mack Zugeschriebenen Operations Plan.*—Bulow, *Betrachtung über Die Kriegs Kunst. Geist des nuern Kriegs System.*—Charles (le Prince), *Principes de la Strategie*, traduit par Jomini. *Campagne de* 1799.—Vaudoncourt, *Campagnes d'Italie en* 1813 *et* 1814.—Dumas, *Precis des Evenemens Militaires.*—Coxe's *Life of Marlborough.*—Pasley, *Essay on the Military Policy and Institutions of the British Empire.*—Jones' *Journals of Sieges.*

(V. V. V.)

Boundaries, Extent, and Divisions.

WARWICKSHIRE, an inland county of England, and nearly in the centre of the kingdom. It is bounded on the western side, from north to south, by Staffordshire, Worcestershire, and Gloucestershire; and on the eastern side by Leicestershire, Northamptonshire, and Oxfordshire. Its greatest length, from north to south, is about forty-eight, and its breadth across the middle thirty-two miles. It contains 902 square miles, or 577,280 statute acres. It is divided into four hundreds, besides the city of Coventry, which, with its liberties, extends over about 18,000 acres. These hundreds are subdivided into eighteen portions, for convenience in the execution of the laws.

Population.

By the census of 1821, it appeared that the number of inhabited houses was 55,082, occupied by 60,123 families: of these 16,779 were chiefly employed in agriculture; 39,189 in trade, manufactures, or handicraft; and 4155 were comprised in neither of those classes. The whole number of persons was 274,392; of whom 133,827 were males, and 140,565 females. The increase of population between the years 1811 and 1821 appears to be about 20 *per cent.*

Face of the Country and Agriculture.

Although Warwickshire is an elevated district, it is in general level; the rivers are of languid course, and the undulations of the surface are rare and gentle. It is generally inclosed, and the fields are of moderate extent. The fences are for the most part high and umbrageous, being thickly planted with forest trees, so that, though woods are rare, the face of the country seems, at a distance, to be one continued track of woodland. There are but few common fields, and very little waste or barren land. The extent of pasture land is greater than in most parts of England, and is estimated to be more than half of the whole. The pasture land, calculated at 300,000 acres, may be said wholly to be appropriated to the sustenance of the different species of animals. 100,000 acres are annually mowed for hay, and the other two-thirds are used for feeding. The agriculture of the county is well conducted. The cultivation of turnips is practised to a great extent, with much skill, and with very productive effects. The crops of wheat, barley, oats, pease, beans, and tares, are quite as luxuriant as in any portion of England. The cows are generally of the long-horned kind, but there are amongst them many varieties. The ancient race of Warwickshire sheep has been crossed with the Leicester breed, and this mixture has produced a kind adapted to the land, and equal to any race in the kingdom.

Rivers and Canals.

The streams of this county are numerous, but, with the exception of the Avon, are inconsiderable; though, by the means of irrigation which they furnish, they are of great value to its rural economy. The whole of them run directly or indirectly to the Severn. The Avon alone is navigable for barges from Stratford to its junction with that river near Tewkesbury. The intercourse of the county is much facilitated by the numerous canals that intersect and connect it with every part of England; supply every part with cheap fuel; and serve to convey its heavy productions to the exporting towns, London, Liverpool, and Bristol. These canals are the Birmingham Old Canal, the Birmingham and Fazeley, the Warwick and Birmingham, the Worcester and Birmingham, the Coventry, the Warwick and Napton, the Stratford, the Ashby de la Zouch, and, above all, the Grand Junction.

Minerals and Mineral Springs.

The minerals and fossils of this county are coal, iron, limestone, and freestone. At Leamington Priors are mineral springs, whose celebrity have made that place one of the resorts of fashionable company as well as invalids. The waters contain neutral and sulphureous salts, with carbonate of iron. At Newham Regis is a chalybeate bath, whose renown was formerly much greater than it is at present.

Manufactures.

This county possesses considerable manufactories; of these, the greatest are those in metals of all kinds, conducted upon a stupendous scale at Birmingham, and the towns and villages in its vicinity. The minute divisions and subdivisions of labour, the various mechanical inventions, the discoveries in chemistry, and the industrious and economical habits of the people, have rendered this part of the country the principal reservoir from whence the world is supplied with domestic utensils, ornaments, and a thousand minute articles which add much to the comfort of civilized life.

Warwick-shire || Waterford.

The city of Coventry has long been celebrated for its manufactures of ribbons, and other goods of silk, which now give occupation, in that place and its vicinity, to more than 15,000 persons. There are also at Coventry large undertakings for making watches; a trade that has of late been much extended. Mills for spinning cotton and wool have been erected at Warwick, and to them is attributed a great increase, which has lately taken place in the population of that town. At Tamworth, very large works are constructed for printing calicoes. At Alcester, several hundred persons are employed in making needles. In several parts of the county much linen yarn is spun.

The most remarkable objects in the county are Kenilworth Castle, now in a dilapidated state; Maxstoke Castle, a most extensive pile; Comb Abbey, a Cistertian Convent; the school-house at Rugby; and the house at Stratford in which Shakespeare was born.

The titles derived from this county are,—Earls of Coventry and Warwick, and Baron Arden. Two members are returned to Parliament for the county, and two each for Coventry and Warwick. Two are also returned for Tamworth, a part only of which borough is in this county.

The largest places and their population are as follows:—Birmingham, 106,722; Coventry, 29,380; Warwick, 8235; Nuneaton, 6610; Sutton Coldfield, 3466; Atherstone, 3434; and Stratford, 3069.

The most remarkable, among a great number of noblemen and gentlemen's seats, are Warwick Castle, Earl of Warwick; Ragley Hall, Marquis of Hertford; Walton Hall, Sir C. Mordaunt; Compton Verney, Lord Willoughby; Guys Cliff, B. Greathead; Great Packington, Lord Aylesford: Compton Wyngate, Marquis of Northampton; Astley Castle; Newdigate; Hewill Grange, Earl of Plymouth; and Merevale, D. S. Dugdale.

See Dugdale's *Antiquities of Warwickshire;* Marshall's *Rural Economy;* Hutton's *History of Birmingham; Beauties of England and Wales.* (W. W.)

WATERFORD, a maritime county in the province of Munster in Ireland, bounded by the river Suir, which separates it from Kilkenny and Tipperary, on the north; by the harbour of its own name, an arm of the sea running up between this county and Wexford, on the east; by the sea on the south; and by the county of Cork on the west, the river Blackwater here flowing along part of its boundary. (Boundaries.)

Extent. It is about 51 miles in length, and 29 in breadth, and contains 710 English square miles, or 454,400 English acres, divided into the liberties of the city of Waterford, and 7 baronies, and including 74 parishes belonging to the Sees of Waterford and Lismore.

Surface. Very little of this district is level, the far greater part being hilly, and much of it mountainous. It is only on the south and east that it is rich and productive; on the west and north, which are occupied by the high grounds, the proportion of fertile land is inconsiderable. Yet the wooded banks of the Suir and the Blackwater, and of the streams that join them, present many delightful and romantic views, diversified by ancient castles and the modern seats of the proprietors.

Rivers. The Suir, which has its source in Tipperary, on the north, after entering this county, flows almost due east, till it joins the Barrow and the Nore, beyond the city of Waterford, and then, taking a southern direction, these united streams enter the sea at the harbour of Waterford; forming an estuary nine Irish miles long and two broad. At the city of Waterford, the Suir is about a mile broad, with a depth sufficient for vessels of considerable burden. The Blackwater rises on the confines of Kerry, and, after traversing the county of Cork, comes into Waterford a little to the east of Fermoy. At Cappoquin, beyond Lismore, where it suddenly bends to the south, it becomes navigable for small vessels, and pursuing its course southwards, falls into the sea at Youghall Bay. The climate of this and the other districts on the south coast of Ireland is exceedingly mild. Frost and snow are never of any duration, and cattle continue to graze all the year round.

Estates. In this county there are some very large estates, of which the most extensive belongs to the Duke of Devonshire. Leases are commonly for twenty-one years and a life; and on the banks of the rivers, where the land is most valuable, farms are small.

Farms. According to Mr Wakefield's information, "in this county, when the eldest daughter of a farmer marries, the father, instead of giving her a portion, divides his farm between himself and son-in-law; the next daughter gets one-half of the remainder, and this division and subdivision continues as long as there are daughters to be disposed of. In regard to the male children, they are turned out into the world, and left to shift for themselves the best way they can." (Wakefield, Vol. I. p. 280.) Mountain land included, the rent in 1808 was computed to be about a guinea and a half the Irish acre, and this is chiefly paid from the produce of the dairy, which is conducted on a greater or smaller scale over all the county, and from the pigs, which are partly fed upon its offals. (Dairies.) Some of the dairy farmers, most of whom are in easy circumstances, at that time paid L. 1000 a-year of rent; and a great deal of butter is made even among the mountains, where small cows, suited to the nature of the pastures, form the principal stock. In the neighbourhood of Waterford, cows were let for L.16, L.18, and even L.20 for the season. There are very few sheep, and those of a bad description; and comparatively but a small portion is in tillage. Where lime is used as a manure, it must be brought from a distance, as there is no limestone to the east of the Blackwater, and it costs upwards of L. 5 for an acre. Orchards are numerous on the banks of this river, and extensive plantations of timber trees have been formed in various parts. Furze is so much used as fuel, that whole fields are kept under this shrub for the purpose.

Towns. The towns are Waterford, Dungarvon, Tallagh, and Lismore, all except the first, places of no great importance. Waterford, situated on the south bank of the Suir, near the harbour which bears its name, and having an inland water communication northwards by the Barrow and Nore, and westward to Clonmell by the Suir, has a population of 26,787, and carries on a considerable trade with the interior and with England, and other countries; and within these few years, it employed 70 vessels in the Newfound-

land trade. Packet boats are established between this port and Milford-haven. It has a noble quay a mile long, with a wooden bridge across the Suir, which affords an easy communication with the counties of Wexford and Kilkenny. Hogs form so important a branch of trade, that the number brought to this town in 1809 was estimated to be worth about L. 1,000,000 Sterling. They are cut up for bacon and hams, which are salted and sent to London, where they are cured by fires made from different kinds of wood, which communicate a corresponding difference of flavour. The principal manufactures are glass and salt; with linen, cotton, and coarse woollens, in other parts of the county. Beef, pork, butter, grain, and linen, are the principal exports: of agricultural produce alone, the export has been estimated at L. 3,000,000 Sterling yearly. By means of the Suir, a great part of the goods imported by Waterford harbour are carried forward to Clonmell for the supply of the interior of Ireland. Part of the provision trade is also carried on at Youghall, situated at the mouth of the Blackwater; the country around it furnishing abundance of pork and grain, but it is not so considerable as formerly. Dungarvon, on the bay of that name, is a fishing town, and this place, and the village of Tramore, a few miles south from Waterford, particularly the latter, are noted for being the residence of the gentry during the bathing season.

Representation. The county, and the city of Waterford, which is a county within itself, with the boroughs of Lismore, Tallagh, and Dungarvon, returned ten members to the Irish Parliament; the number of its representatives is now four, two for the county, one for the city, and one for the borough of Dungarvon. In 1791, the population was computed to be 110,000, and by the census of 1821, it was found to be 127,679. The Protestants, according to Mr Wakefield, bear a very small proportion to the Catholics over the county; and even in the city of Waterford, where the disproportion is not so great as in the country, the latter are increasing in a greater proportion than the former. Most of the landed and personal property is in the hands of the Catholics. The celebrated philosopher Boyle was born in the Castle of Lismore, and also Congreve, the dramatic writer, whose father was agent to the Boyle family, the maternal ancestors of the Duke of Devonshire.

Population.

See the works of Young, Beaufort, Newenham, and Wakefield, quoted under the other Irish counties; Curwen's *Observations on the State of Ireland* (1818), and the *Statistical Accounts of Ireland*. (A.)

WATSON (RICHARD, BISHOP OF LANDAFF), celebrated as an able Theologian, and a Professor of Chemistry, was born in August 1737, at Heversham near Kendal, in Westmorland. His ancestors had been farmers of their own estates for several generations; and his father had for forty years been master of the free school at Heversham, but was become infirm, and had resigned it a little before his birth. He was, however, educated at this school, and continued there till 1754, when he was sent as a sizer to Trinity College, Cambridge. He applied without intermission to his studies, and in 1757 he obtained a scholarship, with particular expressions of approbation from Dr Smith, who was then master. He had made it a constant practice in his mathematical pursuits, to think over the demonstration of every proposition that he studied, in his solitary walks; a habit which must certainly have been very conducive to the improvement of geometrical talent, though it could scarcely be adopted without great labour by those who follow the algebraical mode of analysis in all their investigations. After this period he passed many hours daily, for a considerable portion of his life, in the occupation of instructing others, without much enlarging the scale of his own information, though certainly not without adding to the solidity and precision of his knowledge of the most important elementary truths of science; and when he graduated in 1759, he was classed as the second wrangler, which he seems to have considered, not without reason, as the place of honour for the year, the senior wrangler, who was a Johnian, having, as it was generally believed, been unfairly preferred to him. In October 1760, he became a fellow of Trinity, and in November, assistant tutor of the college. Having taken his degree of M. A. in 1762, he was soon afterwards made moderator of the scholastic exercises of the university, an arduous and honourable office, which he also filled in several subsequent years.

In 1764, he undertook a journey to Paris, though without being able to speak the language, in order to take charge of his young friend and pupil, Mr Luther, who returned to England with him soon after. He was elected in the same year Professor of Chemistry, though he had never devoted any portion of his attention to that science; but he soon rendered himself sufficiently master of all that was then known of the science, to give a very popular course of lectures on the subject about a year after his election, with the assistance of an operator whom he had brought from Paris, and to become the author of a series of essays, which served for many years as the most agreeable introduction to the elementary doctrines and the ordinary processes of chemistry. He obtained from the Government, by proper representations, a salary of L. 100 a year for himself, and for all future professors: he paid also some attention to theoretical and practical anatomy, as having some relation to the science of chemistry. In 1767, he became one of the principal tutors of Trinity College; in 1769, he was elected a Fellow of the Royal Society, and in October 1771, he unexpectedly obtained the important and lucrative appointment of Regius Professor of Divinity, upon the premature death of Dr Rutherford, and in that capacity he held the rectory of Somersham in Huntingdonshire. He had been little accustomed to the study of the divinity of the schools, or even of the fathers; but his eloquence and ingenuity supplied the want of theological learning, though he gave some offence to his more orthodox colleagues, by confining his arguments more strictly to the text of the scripture than they thought perfectly consistent with the duty of a champion of the Church of England, which they considered to be the description of a professor of divinity in an English university. He attracted, however, as long as he officiated in person, audiences as numerous, to the exercises in the schools at which he presided, as had attended his chemical lectures.

Watson.

He married, in December 1773, Miss Wilson, of Dallam Tower in Westmorland; their union continued uninterrupted for more than forty years. In 1774 he obtained a prebend of Ely, in exchange for a rectory in Wales, which the Duke of Grafton had procured for him: and he became Archdeacon of Ely in January 1780; in the same year Bishop Keene presented him with the rectory of Northwold in Norfolk; and, in 1782, his pupil, the Duke of Rutland, gave him the rectory of Knaptoft in Leicestershire: the same interest obtained him also from Lord Shelburne the Bishoprick of Landaff. Here his episcopal preferment rested: he generally joined the politics of the Opposition, and especially on the question of the unlimited regency: but he was too independent in his sentiments to become a very useful member of any administration; and he retired, before the end of the year 1789, without books, and with somewhat more of disgust than he ought in justice to have felt, to an estate which he had bought, at Calgarth, on the banks of Winandermere, and occupied himself entirely, besides the education of his family, in agricultural improvements, especially in planting, for which he received a medal from the Society of Arts in 1789. His pupil Mr Luther, of Ongar in Essex, had died in 1786, and left him an estate, which he afterwards sold for something more than L.20,000.

He considered as one of the best practical results of his chemical studies the suggestion which he made to the Duke of Richmond, then Master of the Ordnance, respecting the preparation of charcoal for gunpowder, by burning the wood in close vessels, which, it seems, very materially improved the quality of the powder.

He had the liberality to confer, in 1804, a small living, as a reward for literary merit only, on Mr Davies, the author of the *Celtic Researches*. The next year, he applied with success to the Duke of York for the promotion of his son, who had then the rank of a Major, and his Royal Highness speedily complied with his solicitation, as a personal favour only, without waiting for any Ministerial influence.

His health had been seriously impaired by an illness which attacked him in 1781, and which his friends attributed, though perhaps without sufficient reason, to excessive study: in October 1809, he had a slight paralytic affection, and another in 1811; but it was in 1813, that his last illness might be said to begin, and he sunk gradually till the 4th of July 1816. The elder of his two sons was in the army, the younger in the church: he left also several daughters. His writings are as miscellaneous as they are numerous; but none of them are bulky.

1. *Institutionum Chemicarum pars Metallurgica.* 8. Cambr. 1768. *Repr. Ess.* Vol. V.

2. *Experiments and Observations on the Solution of Salts. Phil. Trans.* 1770. P. 325. *Ess.* V. Especially on the specific gravities of salts and their solutions. 3. *Remarks on the Effects of Cold in February* 1771. *Phil. Trans.* 1771. P. 213. *Ess.* V. With some experiments on congelation. 4. *Experiment with a Thermometer having its bulb blackened. Phil. Trans.* 1773. P. 40. *Ess.* V. Raised 10°. 5. *Chemical Experiments and Observations on Lead Ore. Phil. Trans.* 1778. P. 863. *Ess.* V. 6. *Observations on the Sulphur Wells at Harrowgate. Phil. Trans.* 1786. P. 171. *Ess.* V.

7. *Essay on the Subjects of Chemistry, and their General Division.*

8. *Assize Sermon, preached at Cambridge.* 4. 1769.

9. *Letters to the Members of the House of Commons by a Christian Whig,* 1772.

10, 11. *Two Sermons.* 4. Cambr. 1776. On the Revolution, and on the King's Accession.

12. *A Brief State of the Principles of Church Authority,* 1773. Reprinted in 1813 as a charge.

13. *A Fast Sermon,* Feb. 1780.

14. *A Sermon addressed to the Clergy of Ely,* 1780. Recommending Oriental Literature.

15. *Apology for Christianity, in a Series of Letters addressed to Edward Gibbon, Esq.* 12. 1776. Often reprinted, and considered as very satisfactory, though the author confesses, with more of the courtier than of the orthodox divine, in a letter to Mr Gibbon, that the *Essay* "derives its chief merit from the elegance and importance of the work it attempts to oppose."

16. *Chemical Essays,* 5 v. 12. 1781-7. Addressed to his pupil the Duke of Rutland. The work was intended for general information, and became extremely popular as a first introduction. The first volume relates to salts, sulphurs, vitriols, and gunpowder; the second to common salt, distillation, lime, clay, and pit coal; the third to bitumens, charcoal, evaporation, lead, and lead ores; and the fourth to zinc, gum, metal, tin, copper, iron, and stones; the fifth is a republication of the author's earlier chemical tracts. After the completion of these volumes, he had the resolution to burn all his chemical papers.

17. *A Letter to Archbishop Cornwallis on the Church Revenues,* 1782. A plan for equalising the bishoprics.

18. *A Sermon preached the 30th Jan. before the Lords.* 4. 1784.

19. *Visitation Articles, for the Diocese of Landaff.*

20. *Theological Tracts.* 6 v. 8. 1785. Collected from various authors, not excluding many works of dissenters from the church.

21. *A Sermon on the Wisdom and Goodness of God, in having made Rich and Poor,* 1785, 1793. Adapted to allay the discontents which were then prevalent among the lower classes.

22. *Sermons and Tracts.* 8. 1788. Chiefly republications.

23. *An Address to Young Persons after Confirmation.* 12. 1789.

24. *Considerations on the Expediency of Revising the Liturgy.* 8. 1790. Anonymous.

25. *A Sermon preached for the Westminster Dispensary in* 1785, *with an Appendix.* 1792.

26. *A Charge to the Clergy of his Diocese.* 4. 1792.

27. *Two Sermons and a Charge.* 4. 1795. The first sermon is entitled *Atheism Refuted;* the second, *The Christian Religion no Imposture.*

28. *Apology for the Bible, in a series of Letters addressed to Thomas Paine.* 12. 1796. An able and judicious answer to the contemptible work of a mischievous incendiary: it seems to have been singularly successful in producing clear and rapid conviction: thanks were returned to the author from

Ireland and from America, and he gained L. 1000 by the sale of the book, besides allowing it to be often reprinted gratuitously.

29. *An Address to the People of Great Britain.* 8. 1798. Enforcing the necessity of submission to the exigencies of the times. It went through fourteen editions, besides several piracies; and it was reprinted in Ireland by order of Lord Camden, then Lord Lieutenant. Mr Wakefield answered it somewhat intemperately, and the Bishop attempted ineffectually, out of respect for his classical acquirements, to lighten the punishment which was allotted to him.

30. *Charge to the Clergy of Landaff.* 31. *Second Charge,* 1802. On similar subjects.

32. *A Charge relating to Ecclesiastical Reform,* 1802.

33. *A Sermon preached at the London Hospital,* 1802. Against the principles of Paine.

34. *Thoughts on the intended Invasion.* 8.

35. *Substance of a Speech intended to have been delivered,* 1804. In favour of Catholic Emancipation.

36. *Sermon preached before the Society for the Suppression of Vice,* 1804.

37. *A Charge to the Clergy,* 1805. 38. *Another Charge, on the Catholic Question,* 1808.

39. *Two Apologies, Two Sermons, and a Charge,* 8. 1806. Reprinted.

40. *A Second Defence of Revealed Religion,* 1807. In two sermons, preached in the Chapel Royal.

41. *A Paper on Planting and on Waste Land.* Communications to the Board of Agriculture, Vol. VII. 4. 1808. 42. He had also written some *Preliminary Observations* in the *Agricultural Report of Westmorland.*

43. *Miscellaneous Tracts.* 2 v. 8. 1815. Religious, political, and agricultural. "His discourse on the first and second Adam, and the nature of death as affected by each, is almost unequalled in originality of thought, and vigour of expression." *Quarterly Review.*

(44). It has been said that he published some papers in the *Manchester Memoirs ;* but they do not appear in the Indices.

45. *Anecdotes of his Life ;* revised in 1814, and published by his son Richard Watson, LL. B. Prebendary of Landaff and Wells. 4. Lond. 1817. *Quarterly Review,* XVIII. P. 229. Treated with great ability, but with too much severity. His chief mistake, indeed, seems to have been, that he expected his literary merits alone to secure him political advancement; further than this, there is nothing disgusting, to a candid reader, in the sincerity with which he displays the consciousness of his own merits. The praises of the reviewer himself are at least as energetic as those of the friends whose language he has occasionally copied; his censures are not less impressive; but for an author's censure of himself, it would be idle to look in a work of autobiography.

Though somewhat reserved, Dr Watson is said to have been remarkable for the simplicity of his manners and the equality of his temper. With respect to his conduct in the school of divinity, the Reviewer confesses that "he ascended the chair with many eminent qualifications for his difficult and distinguished functions. The exercise of four years, as moderator of the philosophical schools, had rendered his faculty of speaking Latin perfectly easy; by great assiduity the vices of his early education had been so far corrected, that a false quantity was never heard to escape him; all the tricks and shifts of school logic were familiar to his mind; in addition to which, his acuteness and ingenuity were admirable. His majestic and commanding figure, his terrific countenance, his deep sonorous voice, the uninterrupted tenor of his sentences, which, though far from classical, were never either barbarous or soloecistic, and above all, the boldness and originality of his sentiments seldom left the under graduates' places unoccupied in the theological school. It was sport to see how the grave professor would glide over the surface of the subject with every appearance of profundity, or when pinned, as his opponent hoped, into a corner, would wind himself out with all the lubricity of an eel. Still he had a large mind; he endured, he encouraged, *he delighted in the opposition of able men ; he never flinched from the strokes of those who had more information than himself,* secure in the consciousness of his own ability to encounter learning by invention. The same tolerance of contradiction, the same dexterity in parrying attacks, he brought with him into private conversation, which rendered him, when the poison of politics did not operate on his constitution, a most agreeable and amusing debater. In these happier hours, and they were not few, he would even smile at the pomp and magnificence of his own manner, and relax into all the *playfulness* and pleasantry which are almost inseparable from *real genius.*"

Our critic appears, however, to have exceeded the limits of candour and of charity, when he asserts that "he was governed through life by the two leading principles of interest and ambition, both of which were thwarted, in his political conduct, by a temper so wayward, and a presumption so overweening, that the disappointment produced by their collision embittered his mind, and exasperated his latter days to a very high degree of malignity. Accomplished as he was in academical learning, he had no ingenuous or disinterested love of knowledge: he read only that he might teach, and he taught only that he might rise."

"When he felt himself neglected, he avowedly and professedly abandoned all study, because, says he, "eagerness in the pursuit of knowledge was a part of my temper till," and only till, "the acquisition of knowledge was attended with nothing but the neglect of the King and his Ministers." Disgusted, therefore, and disappointed, as much as broken in constitution, he withdrew into the wilds of Westmorland without a library, and to this privation he voluntarily submitted almost thirty years. From taste he derived neither amusement nor occupation, for of taste he never had a tincture: placed amidst the most delicious scenes of England, he thought of nothing but turning his own portion of them to emolument!" Thus "this violent declaimer against sinecures and nonresidence was the first who converted the regius professorship of divinity into a sinecure: this enemy of pluralities held at least *fourteen* places of preferment; this man of moderation in his wishes, and calm contentment, under the shade of retirement, spent

the last twenty nine years of his life in 'execrating' [complaining of] those, who, for his factious obstinacy, had left him to that retirement, while he was occupied in nursing up a fortune, till, according to his own boast, with the poorest bishopric in the kingdom, he became the richest bishop upon the bench."

With respect to the merits of the question between him and the administration of his early friend Mr Pitt, there will probably be as many different opinions as there are readers of different political parties; but he had surely no right to expect that a ministry determined to support every minute article of the established constitution of the country, both in church and in state, should voluntarily add to the power and authority of a person who had repeatedly declared himself rather hostile than indifferent to many points which they thought essential to both; or even of one who felt so decided a conviction of the importance of every single opinion which he had himself adopted, as to refuse his concurrence in such measures of legislation, as they might deem of vital importance to the good of the country, and such as had been sanctioned by the concurrent determination of the majority of a cabinet taking on themselves the whole responsibility of their proceedings. He must have been aware that a house divided against itself cannot stand, and that the members of every administration, in a country not despotic, must consent to give up something to each other's feelings, and to make a small sacrifice of private conviction for the great objects of public energy and unanimity. (A. L.)

WATT (JAMES), a philosopher, mechanician, and civil engineer, whose inventive talents, extensive knowledge of the sciences and arts, and practical application of them to the purposes of life, place him in the foremost rank of those illustrious men, whose discoveries have influenced the state of society, and conferred distinction upon their country and age.

His great-grandfather farmed his own small estate in the county of Aberdeen, but engaging in the civil wars, was killed in one of Montrose's battles, and his property lost to his family. His son, Thomas Watt, left an infant, was brought up by relations, and having a turn for the mathematical sciences, made such proficiency by his own exertions, under very untoward circumstances, occasioned by the persecutions of the times, as to enable him at a later and quieter period to establish himself at Greenock, as a teacher of these sciences, and of the dependent arts of surveying and navigation. There he acquired reputation, and dying in 1734, at the advanced age of 91, left a brief record of his partiality to his profession in the inscription upon his tomb in the West Churchyard.*

He had two sons, John and James; the former brought up as a mathematician, settled first at Ayr, and afterwards at Glasgow, where he was much employed in surveying and directing the improvement of estates; was an able man, and drew neatly and accurately, which was not very common in those days. He died in 1737, at an early age, leaving a *Survey of the River Clyde, from Glasgow to the Point of Toward*, which was published by his brother several years afterwards. James, his younger brother, of an active, ingenious, and enterprising mind, became a merchant in Greenock, and was for upwards of twenty years a member of the Town-Council, a magistrate, and a zealous promoter of the improvements of the town. By his wife, Agnes Muirheid, he had two sons, James, the subject of the present article, and John, a youth of promising abilities, who was lost at sea soon after he became of age. Misfortunes in trade, and the decay of the faculties of his mind, occasioned his retirement from business some years before his death, which happened in 1782, in his eighty-fourth year.

James Watt, his eldest son, and only surviving child, was born at Greenock, the 19th January 1736. He received the rudiments of his education in the public schools of his native town; but from the extreme delicacy of his constitution, was with difficulty enabled to attend the classes, and owed much of his acquirements to his studious habits at home. Little more is known of his early years, than that, from the first, he manifested a partiality for mechanical contrivances and operations, and frequently employed himself in that way. The desire of improvement in an art then little practised in Scotland, induced him to go to London in his eighteenth year, and there to place himself under the tuition of a mathematical instrument-maker; but he remained little more than a twelvemonth, the infirm state of his health compelling his return to the paternal roof.

In that short period, he appears to have made great proficiency, and continued, after his return to Scotland, to perfect himself in this art, both at home and on his visits to his mother's relations at Glasgow, where it was his wish to establish himself. But some opposition being made by the corporations, who considered him as an intruder upon their privileges, the Professors of the College took him under their protection, and accommodated him with an apartment and premises for carrying on his business within their precincts, with the title and office of *Mathematical Instrument-maker to the University*. This took place in 1757, when he was twenty-one years of age, and it must be inferred, that he had already given satisfactory proofs of talent to the eminent men who then adorned that seat of learning; of whom it is sufficient to mention the names of Robert Simpson, Adam Smith, Dr Black, and of Dr Dick, the Professor of Natural Philosophy. There Mr Watt applied sedulously to business, and in the few intervals which its concerns, and ill health allowed, cultivated those various talents which distinguished him in after life; and there a lasting friendship was formed with the kindred minds of Dr Black, and of Mr, afterwards Dr John, Robison, then a student at the University, and nearly of his own age.

He remained in the College until some time in the year 1763, when he removed into the town previous to his marriage with his cousin, Miss Miller, which took place in the summer of the following year.

The Steam-Engine had been a frequent subject of conversation between Mr Robison and himself, and

* He is there styled, Professor of the Mathematics.

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the former had suggested the possibility of its application to the moving of wheel carriages. About the year 1761 or 1762, Mr Watt had tried some experiments on the force of steam in a Papin's digester, and had constructed and worked with strong steam a small model, consisting of an inverted syringe; the bottom of the rod of which was loaded with a weight, alternately admitting the steam below the piston, and letting it off to the atmosphere. Observing the imperfections of this construction, he soon abandoned it; but the attention necessary to be bestowed upon his business prevented his reconsidering it, until the winter of 1763-4, when he was employed by the Professor of Natural Philosophy to put in order a working model of a steam-engine upon Newcomen's construction. When he had repaired it and set it to work, he found that the boiler, though large in proportion to the cylinder, was barely able to supply it with steam for a few strokes *per* minute, and that a great quantity of injection water was required, though it was but lightly loaded by the pump attached to it. It soon occurred, that the cause lay in the little cylinder (two inches diameter, six inches stroke), exposing a greater surface to condense the steam than the cylinders of larger engines did, in proportion to their respective contents. By shortening the column of water in the pump, less steam and less injection water were required, and the model worked at a proper speed. Thus the purpose for which it was put into his hands was accomplished; and with this mode of accounting for the defect and this result, most artists would have been satisfied. Not so Mr Watt. He had now become aware of a great consumption of steam, and his curiosity was excited to a more accurate investigation of the causes, in which he proceeded in a truly philosophical manner. The cylinder of his small model being of brass, he conceived that less steam would be condensed by substituting cylinders of some material which would transmit heat more slowly. He made a larger model with a cylinder (six inches diameter, and one foot stroke) of wood, soaked in oil, and baked to dryness. He ascertained, from experiments made with boilers of various constructions, that the evaporation of boiling water is neither in proportion to the evaporating surface, nor to the quantity of water, as had been supposed, but to the heat that enters it; and that the latter depended chiefly on the quantity of surface exposed to the action of the fire. He likewise determined the weight of coal required for the evaporation of any given quantity of water. Being convinced that there existed a great error in the statement which had been previously given of the bulk of water when converted into steam, he proceeded to examine that point by experiment; and discovered, that water, converted into steam of the heat of boiling water, was expanded to 1800 times its bulk: or, as a rule for ready calculation, that a cubic inch of water produced a cubic foot of steam. He constructed a boiler to be applied to his model, which should show, by inspection, the quantity of water evaporated, and, consequently, would enable him to calculate the quantity of steam used in every stroke of the engine. This he now proved to be several times the full of the cylinder. He also observed, that all attempts to improve the vacuum, by throwing in more injection water, caused a disproportionate waste of steam: and it occurred to him, that the cause of this was the boiling of water in vacuo at very low heats (recently determined, by Dr Cullen, to be under 100°); consequently, at greater heats, the injection water was converted into steam in the cylinder, and resisted the descent of the piston. He now perceived clearly, that the great waste of steam proceeded from its being chilled, and condensed by the coldness of the cylinder before it was sufficiently heated to retain it in an elastic state; and that, to derive the greatest advantage, the cylinder should always be kept as hot as the steam that entered it, and that, when the steam was condensed, it should be cooled down to 100°, or lower, in order to make the vacuum complete. Early in 1765, the fortunate thought occurred to him of accomplishing this, by condensing the steam in a separate vessel, exhausted of air, and kept cool by injection, between which and the cylinder a communication was to be opened every time steam was to be condensed, while the cylinder itself was to be kept constantly hot. No sooner had this occurred to him, than the means of effecting it presented themselves in rapid succession. These have been in a great measure already described in the *Encyclopædia.* A model was constructed, and the experiments made with it, placed the correctness of the theory, and the advantages of the invention, beyond the reach of doubt.

In the course of these trials, he was much struck by the great heat communicated to the injection water by a small quantity of steam, and proceeded by a very simple experiment to satisfy himself upon that subject, when he discovered that water converted into steam will heat about six times its own weight of water at 47° or 48° to 212°. He mentioned this extraordinary fact to Dr Black, who then explained to him his doctrine of latent heat, to the support of which, Mr Watt had afterwards the satisfaction of contributing his experiments. From some of these he was led to suppose the latent heat of steam to be above 1000°, but he afterwards considered 960° a more accurate determination. From others, he deduced the important conclusion, that the sum of the latent and sensible heat of steam, at different temperatures, is a constant quantity, the latent heat increasing as the sensible heat diminishes; or, in other words, that a given weight of water in the state of steam contains nearly the same quantity of heat, whatever may be the bulk or density of the steam.

He also, at this time, made experiments upon the capacities of different bodies for heat, and upon the heats at which water boils under various pressures; from which he ascertained, that where the heats proceeded in an arithmetical, the elasticities proceeded in a geometrical ratio, the curve of which he laid down. These he repeated some years after with more accuracy.

We have been thus minute in our details of the successive steps by which Mr Watt proceeded to his great improvement upon the principle of the steam-engine, in order to convey some idea of the sagacity, ingenuity, and science, with which he conducted the investigation. Our limits will oblige us to be more brief in our narrative of his subsequent improvements.

From this period (the early part of 1765), his mind

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became very much engaged in contriving the machinery for executing his improvement upon a large scale; but the want of funds prevented his attempting it, until he was induced to address himself to Dr Roebuck, who had a short time before completed his establishment of the Carron Ironworks, and who, in addition to his known qualities of ingenuity and enterprise, was considered to be possessed of ample means of introducing the invention to the public. He agreed to enter into the plan, upon having the proceeds of two-thirds of the invention assigned to him; and an engine upon a large scale was then constructed by Mr Watt, at Kinneil, near Borrowstounness, where the Doctor then resided; the trials made with which gave satisfaction. But the introduction of the invention to the public was retarded, on the one hand, by the pecuniary difficulties in which the Doctor became involved, by the failure of several of his multifarious undertakings; and on the other, by the employment, which the rising reputation of Mr Watt, for knowledge and skill in the line of a civil engineer, procured him.

He was employed, in 1767, to make a survey for a canal of junction between the rivers Forth and Clyde, by what was called the Lomond passage, and attended Parliament on the part of the subscribers, where the bill was lost. An offer was then made to him of undertaking the survey and estimate of an intended canal from the Monkland Colleries to Glasgow; and these proving satisfactory, the superintendence of the execution was confided to him. This was quickly followed by his being employed by the *Trustees for Fisheries and Manufactures in Scotland*, to make a survey of a canal from Perth to Forfar, through Strathmore; and soon afterwards, by the *Commissioners of the Annexed Estates*, to furnish a report and estimate of the relative advantages of opening a communication between the Firth of Clyde and the Western Ocean, by means of a navigable canal across the isthmus of Crinan,* or that of Tarbert. Business of this description now crowded upon him; and surveys, plans, and estimates, were successively undertaken by him for the harbours of Ayr, Port-Glasgow, and Greenock; the deepening of the river Clyde; the rendering navigable the rivers Forth and Devon, and the water of Leven; the making of a canal from Machrihanish bay to Campbelltown, and of another between the Grand Canal and the harbour of Borrowstounness; the building of bridges at Hamilton and at Rutherglen, &c. &c. In these surveys he made use of a new micrometer, and a machine for drawing in perspective, which he had invented to facilitate his operations. Our limits do not allow us to go into the details of his *Reports*, which are remarkable for their perspicuity and accuracy, although the work of a self-taught engineer. The last and greatest work upon which he was employed was the survey and estimate of the line of a canal between Fort-William and Inverness, since executed by Mr Telford, upon a larger scale than was at that time proposed, under the name of the Caledonian Canal.

Whilst engaged upon this survey, in the latter part of the year 1773, Mr Watt received the account of the death of his affectionate wife, leaving him a daughter and a son. He appears soon after to have made up his mind to adopt the advice of his friend Dr Small of Birmingham, and the invitation of Mr Boulton, to settle in England. He had secured his title to his *Improvements for saving Steam and Fuel in Fire Engines*, by patent, in the year 1769; but all hopes of carrying them into effect, by the assistance of Dr Roebuck, being at an end, he had induced that gentleman to agree, for certain considerations, to transfer his share of the patent to Mr Boulton of Soho, near Birmingham—a gentleman equally distinguished by his knowledge of the arts, and his enterprising spirit, who had some years before established his manufactory upon a scale as unrivalled for extent and elegance, as for the variety and perfection of the processes carried on.

In conjunction with him an application was made to Parliament for an extension of the term of the patent, and an act prolonging it for twenty-five years was obtained in the year 1775, when the business of making steam-engines was commenced by the firm of Boulton and Watt.

Mr Watt now married for his second wife Miss Macgrigor, the daughter of an old friend, at Glasgow, and devoted himself to the improvement of the details of the engine with a degree of application and exertion not to be expected from his delicate and infirm state of health; and he found in his partner a zealous and able coadjutor.

Some engines for pumping water were soon made upon a large scale, and the savings in fuel were demonstrated by repeated comparative trials to amount to three-fourths of the quantity consumed by those of the best construction before in use. A deputation from the mining interest of Cornwall was sent to ascertain the fact, and their report led to the introduction of the improved engines into that county, to which they have proved of such vast utility.

The immediate application of the powers of steam to giving a rotary motion to mills had formed an early object of Mr Watt's attention, and he had deeply considered the various means of effecting this. One method of producing a continued movement in one direction was by a steam wheel, described in his patent of 1769. Various others of a similar kind suggested themselves to him, of some of which drawings and models were made; but the difficulty of rendering them steam and air-tight, and the loss of power by friction, induced him to turn his thoughts to the adaptation of the reciprocating motion to the production of a continued regular rotary one. This he accomplished by a series of improvements, the exclusive property of which he secured by successive patents in the years 1781, 1782, 1784, and 1785; including, among other inventions, the rotary motion of the sun and planet wheels, † the expansive principle, the double engine, the parallel motion, and the

* The Crinan Canal was executed several years afterwards, under the direction of his friend Mr Rennie, with some variations.

† Mr Watt had originally intended to derive the rotary motion from the working beam by means of a connecting rod and crank; but the workman employed to make the model communicated it to a neighbour-

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smokeless furnace. The application of the centrifugal regulating force of *the governer* gave the finishing stroke to the machine.

The invention of the separate condenser, and the contrivances necessary to give it full effect, would alone have established the fame of Mr Watt; but when to these are added the various inventions called forth to perfect his rotative engines, we are impressed by a union of philosophical research, of physical skill, and of mechanical ingenuity, which has, we believe, no parallel in modern times.

The perfection thus given to the rotative engine soon led to its general application for imparting motion to almost every species of mill-work and machinery; and gave an impulse, unexampled in the history of inventions, to the extension of our manufactures, population, and wealth.

Nor were Mr Watt's inventive powers confined to the steam-engine. The necessity of preserving accurate copies of his various drawings and of his letters, containing long and important calculations; and the desire of avoiding that labour himself, which he did not think it right to entrust to others, led him, in the year 1780, to contrive a copying apparatus, the exclusive property in which he secured by Letters Patent, and commenced the manufactory of them in partnership with Mr Boulton, and his friend, Mr Keir, under the firm of James Watt and Company;—a contrivance of great simplicity, and of which he reaped an ample benefit in the time, labour, and expence it saved to himself, to say nothing of its advantages to the public.

In the winter of 1784–5, he put up an apparatus for heating the room in which he drew and wrote by means of steam. The possibility of doing this we find suggested by Colonel Cooke in the *Philosophical Transactions* for 1745; but we know not whether this was known to Mr Watt when he made this first practical attempt, from which he deduced proportions of surface, &c., which afterwards served to guide his firm in the introduction of the process in larger buildings.

Chemical studies engaged much of his attention during his busiest time, and at the very period when he was most engaged in perfecting his rotative engines, and in managing a business become considerable, and, from its novelty, requiring close attention, he entered deeply into the investigations then in progress relative to the constitution and properties of the different gases. Early in 1783, he was led, by the experiments of his friend and neighbour, Dr Priestley, to the important conclusion, that water is a compound of dephlogisticated and inflammable airs (as they were then called) deprived of their latent or elementary heat, and he was the first to make known this theory. This was done in a letter to Dr Priestley, dated the 28th April 1783, in which he states the Doctor's experiments to have come in aid of some prior notions of his own, and supports his conclusions by original experiments. That letter Dr Priestley received in London; and, after showing it to several members of the Royal Society, he delivered it to Sir Joseph Banks, with a request that it might be read at some of the public meetings of the Society; but before that could be complied with, Mr Watt, having heard of some new experiments made by Dr Priestley, begged that the reading might be delayed. Those new experiments soon afterwards proved to have been delusive, and Mr Watt sent a revised edition of his letter to Mr De Luc on the 26th November of the same year, which was not read to the Society until the 29th April 1784, and appears in the *Philosophical Transactions* for that year, under the title of *Thoughts on the Constituent Parts of Water and of Dephlogisticated Air, with an Account of some Experiments upon that Subject.* In the interim, on the 15th January 1784, a paper by Mr Cavendish had been read, containing his *Experiments on the Combustion of the Dephlogisticated and Inflammable Airs,* and drawing the same inference as Mr Watt; with this difference only, that he did not admit elementary heat into his explanation. He refers in it to his knowledge of Mr Watt's paper, and states his own experiments to have been made in 1781, and mentioned to Dr Priestley; but he does not say at what period he formed his conclusions; he only mentions that a friend of his had given some account of his experiments in the summer of 1783 to Mr Lavoisier, as well as of the conclusion drawn from them. It is quite certain, that Mr Watt had never heard of them; and Dr Blagden has stated, that he mentioned at Paris the opinions of both the English philosophers, which were not admitted without hesitation, nor until the French chemists had satisfied themselves by experiments of their own. *

Mr Watt also has the merit of being the first person to introduce into this country, and to carry into effect, on a practical scale, in any country, the bleaching of linens and cottons by oxymuriatic acid, the invention of his friend, Mr Berthollet. That gentleman had communicated his invention to Mr Watt at Paris in the winter of 1786–7, whither he had proceeded with Mr Boulton at the instance of the French government, to suggest improvements in the mode of raising water at Marly, and his mind was instantly alive to the extensive application of which it admitted. He advised Mr Berthollet to secure the property by an English patent; but that he declined, and left his friend to make such use of it

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ing manufacturer, who took out a patent for it. This stimulated Mr Watt to the invention of other means of effecting the same object, of which five are described in his patent of 1781. He afterwards used the crank, which was indeed his own, when he saw occasion, in defiance of the patentee, who never troubled him.

* There is a confusion of dates in the accounts of this affair. Mr Watt's letter to Mr De Luc in the *Philosophical Transactions* appears dated 26th November 1784, which is evidently an error of the press. Mr Cavendish, in his letter, read 15th January 1784, speaks of Mr Watt's paper " as lately read before the Society," whereas the paper itself purports to have been read on the 29th April 1784. This we cannot explain.

as he thought proper. He, in consequence, communicated it to his father-in-law, Mr Macgrigor, and gave directions for the construction of the proper vessels and machinery; and soon after himself superintended the first trials at his bleachfield near Glasgow, which proved eminently successful.

Some years after this, Mr Watt was led, by the illness of the daughter, and some apprehensions entertained for the son, who were the issue of his second marriage, to consider the subject of the medical application of the factitious airs, and to contrive various apparatuses for that purpose, which were described by himself, in his friend Dr Beddoes's publications on *Pneumatic Medicine*.

We have not space to particularize other improvements introduced by Mr Watt, or at his suggestion, into various arts; for there were few arts with the details of which he was not intimately acquainted, and to the practical professors of which he was not able and willing to impart information. We shall only mention, that, before he left Glasgow to settle in England, he had assisted some of his friends in the establishment of a pottery there, to the success of which his experiments and advice had greatly contributed, and in which he afterwards continued a partner. At a later period, he occupied himself much upon a composition, having the transparency, and nearly the hardness of marble, from which he made many casts. This promoted, if it did not create a taste for sculpture and statuary, and led to his employing himself, during the last years of his life, in the contrivance of a machine for multiplying busts and other carved work, which he left in a very forward state.

Mr Watt did not escape the common lot of eminent men, that of meeting with pirates of his inventions, and detractors from his merit. The latter, indeed, were but few, and their efforts transitory; but the former were numerous, and in proportion to the benefits expected to arise from an evasion of the patent dues claimed by Boulton and Watt; though these were established upon the liberal footing of receiving only one-third of the savings of fuel compared with the best steam-engines previously in use. In consequence, the attention both of Mr Watt and of Mr Boulton was greatly occupied, from the year 1792 to the year 1799, in defending their patent rights against numerous invaders, the principal of whom were supported by a portion of the mining interest of Cornwall, although the respectable part of it refused to concur in their measures. The admission of their respective sons into the partnership, in 1794, infused vigour into their proceedings; and, after repeated verdicts, establishing the novelty and utility of Mr Watt's inventions, the validity of his claim was finally confirmed in the year 1799 by the unanimous decision of all the Judges of the Court of King's Bench.

In 1800, upon the expiration of the act of Parliament passed in his favour, he withdrew from business, resigning his shares to his two sons; of whom the youngest, Mr Gregory Watt, died soon after, having given splendid proofs of literary and philosophical talents, and left a durable record of the latter, in his paper *On Basalt* in the *Philosophical Transactions*. Mr Watt continued to the close of life to interest himself in the pursuits of his former associates, and to maintain an uninterrupted friendship with Mr Boulton, whom he survived several years.

On two occasions afterwards, in 1811 and 1812, he gave proofs of the undiminished powers of his mind in his former profession. In the one instance, he was induced, by his grateful recollections of his residence in Glasgow, to assist the proprietors of the water-works there with a plan for supplying the town with better water, by means of a suction pipe, with flexible joints, laid across the bottom of the Clyde, accompanied with instructions for insuring the supply of water on the opposite side; a plan which answered completely, and for which the proprietors presented him with a handsome memorial of their gratitude. In the other instance, he was prevailed upon by the earnest solicitation of the Lords Commissioners of the Admiralty, to attend a deputation of the Navy Board, and to give with his friend, Captain Huddart, and Mr J. Jessop, an opinion upon the works then carrying on at Sheerness Dockyard, and the farther ones projected by Messrs Rennie and Whidby; on which occasion, he no less gratified the gentlemen associated with him, by the clearness of his general views, than by his knowledge of the details, and received the thanks of the Admiralty.

Mr Watt, also, at a still later period, in 1814, yielded to the wishes of his friends in undertaking a revision of Professor Robison's articles on STEAM and STEAM-ENGINES in the *Encyclopædia Britannica;* and enriched them with valuable notes, containing his own experiments upon steam, and a short history of his principal improvements upon the engine itself.

His originally infirm health had been subjected to severe trials by the great exertions of his mind, during the period of carrying into execution his improvements on the steam-engine, and had with difficulty resisted the cares and anxieties attending upon business, and those created by the subtleties of the law, during the protracted proceedings of seven long years. There appears to have been an organic defect in his digestion, and its effects were intensely severe sick headachs; but, by continual temperance and good management of his constitution, which he treated with much medical skill, it improved as he advanced in years; and with faculties little impaired he reached his 84th year, when, after a short illness, rather of debility than of pain, he expired in the bosom of his family at his house at Heathfield, in the county of Stafford, on the 25th August 1819.

His remains are deposited in the chancel of the adjoining parochial church of Handsworth, near those of Mr Boulton. An excellent bust had been made of him, some years before his death, by Mr Chantry, and a statue is now nearly finished by the same great artist; intended by filial piety to be placed upon his tomb, and to convey to distant ages a faithful representation of those features in which the lines of intense thought were blended with the mild expression of benevolence.

Mr Watt was elected a member of the Royal Society of Edinburgh in 1784; of the Royal Society of London in 1785; and a corresponding member of the Batavian Society in 1787. In 1806, the hono-

Watt. rary degree of Doctor of Laws was conferred upon him by the spontaneous and unanimous vote of the Senate of the University of Glasgow; and in 1808, he was elected first a corresponding, and afterwards a foreign member of the Institute of France.

In this brief narrative of his long, busy, and useful life, we have endeavoured to confine ourselves to a statement of the principal facts, and shall now add the Character drawn up, soon after his death, by a distinguished writer, who knew him well, and enjoyed a large portion of his esteem.

"It is with pain that we find ourselves called upon, so soon after the loss of Mr Playfair, to record the decease of another of our illustrious countrymen, and one to whom mankind has been still more largely indebted—Mr James Watt, the great improver of the steam-engine.

"This name fortunately needs no commemoration of ours; for he that bore it survived to see it crowned with undisputed and unenvied honours; and many generations will probably pass away before it shall have 'gathered all its fame.' We have said that Mr Watt was the great *improver* of the steam-engine; but, in truth, as to all that is admirable in its structure, or vast in its utility, he should rather be described as its *inventor*. It was by his inventions that its action was so regulated as to make it capable of being applied to the finest and most delicate manufactures, and its power so increased as to set weight and solidity at defiance. By his admirable contrivances, it has become a thing stupendous alike for its force and its flexibility,—for the prodigious power which it can exert, and the ease, and precision, and ductility, with which it can be varied, distributed, and applied. The trunk of an elephant that can pick up a pin or rend an oak is as nothing to it. It can engrave a seal, and crush masses of obdurate metal like wax before it,—draw out, without breaking, a thread as fine as gossamer, and lift a ship of war like a bauble in the air. It can embroider muslin and forge anchors,—cut steel into ribbands, and impel loaded vessels against the fury of the winds and waves.

"It would be difficult to estimate the value of the benefits which these inventions have conferred upon the country. There is no branch of industry that has not been indebted to them; and in all the most material, they have not only widened most magnificently the field of its exertions, but multiplied a thousandfold the amount of its productions. It is our improved steam-engine that has fought the battles of Europe, and exalted and sustained, through the late tremendous contest, the political greatness of our land. It is the same great power which now enables us to pay the interest of our debt, and to maintain the arduous struggle in which we are still engaged, with the skill and capital of countries less oppressed with taxation. But these are poor and narrow views of its importance. It has increased indefinitely the mass of human comforts and enjoyments, and rendered cheap and accessible all over the world the materials of wealth and prosperity. It has armed the feeble hand of man, in short, with a power to which no limits can be assigned, completed the dominion of mind over the most refractory qualities of matter, and laid a sure foundation for all those future miracles of mechanic power which are to aid and reward the labours of after generations. It is to the genius of one man, too, that all this is mainly owing; and certainly no man ever before bestowed such a gift on his kind. The blessing is not only universal, but unbounded; and the fabled inventors of the plough and the loom, who were deified by the erring gratitude of their rude contemporaries, conferred less important benefits on mankind than the inventor of our present steam-engine. Watt.

"This will be the fame of Watt with future generations; and it is sufficient for his race and his country. But to those to whom he more immediately belonged, who lived in his society, and enjoyed his conversation, it is not perhaps the character in which he will be most frequently recalled—most deeply lamented—or even most highly admired. Independently of his great attainments in mechanics, Mr Watt was an extraordinary, and in many respects a wonderful man. Perhaps no individual in his age possessed so much and such varied and exact information,—had read so much, or remembered what he had read so accurately and well. He had infinite quickness of apprehension, a prodigious memory, and a certain rectifying and methodising power of understanding, which extracted something precious out of all that was presented to it. His stores of miscellaneous knowledge were immense,—and yet less astonishing than the command he had at all times over them. It seemed as if every subject that was casually started in conversation with him, had been that which he had been last occupied in studying and exhausting;—such was the copiousness, the precision, and the admirable clearness of the information which he poured out upon it without effort or hesitation. Nor was this promptitude and compass of knowledge confined in any degree to the studies connected with his ordinary pursuits. That he should have been minutely and extensively skilled in chemistry and the arts, and in most of the branches of physical science, might perhaps have been conjectured; but it could not have been inferred from his usual occupations, and probably is not generally known, that he was curiously learned in many branches of antiquity, metaphysics, medicine, and etymology, and perfectly at home in all the details of architecture, music, and law. He was well acquainted, too, with most of the modern languages—and familiar with their most recent literature. Nor was it at all extraordinary to hear the great mechanician and engineer detailing and expounding, for hours together, the metaphysical theories of the German logicians, or criticising the measures or the matter of the German poetry.

"His astonishing memory was aided, no doubt, in a great measure, by a still higher and rarer faculty—by his power of digesting and arranging in its proper place all the information he received, and of casting aside and rejecting, as it were instinctively, whatever was worthless or immaterial. Every conception that was suggested to his mind seemed instantly to take

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its place among its other rich furniture, and to be condensed into the smallest and most convenient form. He never appeared, therefore, to be at all encumbered or perplexed with the *verbiage* of the dull books he perused, or the idle talk to which he listened; but to have at once extracted, by a kind of intellectual alchemy, all that was worthy of attention, and to have reduced it for his own use, to its true value and to its simplest form. And thus it often happened that a great deal more was learned from his brief and vigorous account of the theories and arguments of tedious writers, than an ordinary student could ever have derived from the most faithful study of the originals,—and that errors and absurdities became manifest from the mere clearness and plainness of his statement of them, which might have deluded and perplexed most of his hearers without that invaluable assistance.

"It is needless to say, that, with those vast resources, his conversation was at all times rich and instructive in no ordinary degree; but it was, if possible, still more pleasing than wise, and had all the charms of familiarity, with all the substantial treasures of knowledge. No man could be more social in his spirit, less assuming or fastidious in his manners, or more kind and indulgent towards all who approached him. He rather liked to talk,—at least in his later years; but though he took a considerable share of the conversation, he rarely suggested the topics on which it was to turn, but readily and quietly took up whatever was presented by those around him, and astonished the idle and barren propounders of an ordinary theme, by the treasures which he drew from the mine they had unconsciously opened. He generally seemed, indeed, to have no choice or predilection for one subject of discourse rather than another; but allowed his mind, like a great cyclopædia, to be opened at any letter his associates might choose to turn up, and only endeavoured to select from his inexhaustible stores what might be best adapted to the taste of his present hearers. As to their capacity he gave himself no trouble; and, indeed, such was his singular talent for making all things plain, clear, and intelligible, that scarcely any one could be aware of such a deficiency in his presence. His talk, too, though overflowing with information, had no resemblance to lecturing or solemn discoursing, but, on the contrary, was full of colloquial spirit and pleasantry. He had a certain quiet and grave humour, which ran through most of his conversation, and a vein of temperate jocularity, which gave infinite zest and effect to the condensed and inexhaustible information, which formed its main staple and characteristic. There was a little air of affected testiness, and a tone of pretended rebuke and contradiction, with which he used to address his younger friends, that was always felt by them as an endearing mark of his kindness and familiarity,—and prized accordingly, far beyond all the solemn compliments that ever proceeded from the lips of authority. His voice was deep and powerful,—though he commonly spoke in a low and somewhat monotonous tone, which harmonised admirably with the weight and brevity of his observations, and set off to the greatest advantage the pleasant anecdotes which he delivered with the same grave brow and the same calm smile playing soberly on his lips. There was nothing of effort, indeed, or impatience, any more than of pride or levity, in his demeanour; and there was a finer expression of reposing strength, and mild self-possession in his manner, than we ever recollect to have met with in any other person. He had in his character the utmost abhorrence for all sorts of forwardness, parade, and pretension; and, indeed, never failed to put all such impostors out of countenance, by the manly plainness and honest intrepidity of his language and deportment.

"In his temper and dispositions he was not only kind and affectionate, but generous, and considerate of the feelings of all around him, and gave the most liberal assistance and encouragement to all young persons who showed any indications of talent, or applied to him for patronage or advice. His health, which was delicate from his youth upwards, seemed to become firmer as he advanced in years; and he preserved, up almost to the last moment of his existence, not only the full command of his extraordinary intellect, but all the alacrity of spirit, and the social gaiety which had illuminated his happiest days. His friends in this part of the country never saw him more full of intellectual vigour and colloquial animation,—never more delightful or more instructive than in his last visit to Scotland in autumn 1817. Indeed, it was after that time that he applied himself, with all the ardour of early life, to the invention of a machine for mechanically copying all sorts of sculpture and statuary,—and distributed among his friends some of its earliest performances, as the productions of a young artist just entering on his 83d year.

"This happy and useful life came at last to a gentle close. He had suffered some inconvenience through the summer; but was not seriously indisposed till within a few weeks from his death. He then became perfectly aware of the event which was approaching; and with his usual tranquillity and benevolence of nature, seemed only anxious to point out to the friends around him the many sources of consolation which were afforded by the circumstances under which it was about to take place. He expressed his sincere gratitude to Providence for the length of days with which he had been blessed, and his exemption from most of the infirmities of age, as well as for the calm and cheerful evening of life that he had been permitted to enjoy, after the honourable labours of the day had been concluded. And thus, full of years and honours, in all calmness and tranquillity, he yielded up his soul, without pang or struggle,—and passed from the bosom of his family to that of his God!

"He was twice married, but has left no issue but one son, long associated with him in his business and studies, and two grandchildren by a daughter who predeceased him. He was a Fellow of the Royal Societies both of London and Edinburgh, and one of the few Englishmen who were elected members of the National Institute of France. All men of learning and science were his cordial friends; and such was the influence of his mild character and perfect fairness and liberality, even upon the pretenders to

these accomplishments, that he lived to disarm even envy itself, and died, we verily believe, without a single enemy."*

WEAVING BY POWER. See the Article Cotton-Manufacture, in this *Supplement*, Vol. III. p. 400.

WEIGHTS AND MEASURES.

The bill for ascertaining and establishing Uniformity of Weights and Measures, which passed the Imperial House of Commons in the Session of 1823, not having been carried through the House of Lords, the subject has less immediate interest at the present moment than there has been every reason to suppose, for a few years past, that it would by this time have acquired. But there is little doubt that the discussion will be revived either in the Upper or the Lower House of Parliament before many more months have elapsed; and it seems to be highly improbable that any insuperable difficulties should stand in the way of its ultimate success. This presumption is founded on no hasty view of the subject in question, but upon a laborious and somewhat painful examination of the historical progress of the measures which have been taken respecting it, and especially of the laws of England respecting uniformity of practice in different parts of the country; a uniformity which, though generally esteemed by all governments a thing to be encouraged and enforced, has often proved to be no more subjected to the controul of legislative enactment, than the introduction of a uniformity of language and a grammatical accuracy of speech would be found in every part of an extensive empire.

Augustus is said to have endeavoured in vain to force a new Latin word into the language of ancient Rome; the French, on the other hand, after all their labours to recommend a uniform system of measures, have ended in such a complication, that for the most simple purposes of practical mechanics and civil life, it is become usual to carry in the pocket a little ruler, in the form of a triangular prism, one of the sides containing the old established lines and inches of the royal foot, a second the millimetres, centimetres, and decimetres of the revolutionary school, and the third the new ultraroyal combination of the Jacobin measure, with the royal division, the inches consisting each of the 36th part of a metre, or the four millionth of a degree of the meridian of the earth. If such occurrences as these be calmly considered, they will make us more disposed to diminish than to increase the number of penal statutes intended to compel the inhabitants of the different parts of a country to study their own convenience conjointly with that of their neighbours, and to spare themselves the necessity of a few arithmetical operations in the course of every market day; and we shall feel that it is more incumbent on a wise government to endeavour to facilitate both the attainment of correct and uniform standards of legal existing measures of all kinds, and the ready understanding of all the provincial and local terms applied to measures, either regular or irregular, by the multiplication of glossaries and tables for the correct definition and comparison of such terms.

Measures have apparently always been derived, in the first instance, from some part of the human person; a foot, a pace, a fathom, the orgyia or stretch of the arms, a cubit, a palm, and a finger; these have probably all been used in the earlier states of society by each individual from the magnitude of his own person; and afterwards a standard measure has been established by authority from the real or supposed magnitude of the person of some king or hero, in order for the attainment of more perfect uniformity in practice; though it is said, that in some parts of the East the Arabs still measure the cubits of their cloth by the fore arm, with the addition of the breadth of the other hand, which serves to mark the end of the measure, as the thumb which was formerly added at the end of the yard by the English clothiers. It ought not, however, to be forgotten, that any one of these terms possesses an advantage, for popular use and for the convenience of future ages and of remote countries, which would be lost by the introduction of any more arbitrary measurement; thus a hand's breadth, or a foot, is always sufficiently understood, without any definition, to enable us to form to ourselves a tolerable accurate picture of the magnitude intended to be described; and there is scarcely an instance of the caprice of denomination having ever extended so far as to make the measure called a foot in any country so small as half a natural foot, or so great as two feet of an ordinary person, and certainly not of its amounting to three ordinary feet; while a metre, even to those who know that the word implies a measure, might as well have meant a mile, or an inch, or a quart, as a length somewhat greater than a yard.

The idea of accurately verifying the standard of a country by any other means, than that of a comparison with some actually existing original, can scarcely have occurred, except in a very advanced period of the progress of civilisation. It was indeed enacted, in the time of our Henry the Third, that an ounce should be the weight of 640 dry grains of wheat taken from the middle of the ear, that a pound should be twelve ounces, a gallon of wine eight pounds, and eight gallons of wine a bushel of London; but this seems rather a direction for making a single standard than a mode intended for the continual verification of the standard in case of any minute uncertainty. Again, in a statute of Henry the Seventh, a gallon of corn was mentioned as containing eight pounds of wheat: and this may, perhaps,

* The Editor has received this article from a quarter which entitles him to state, with the utmost confidence, that it contains an accurate and faithful account of Mr Watt. The brilliant eulogium with which it so properly concludes is known to have been written by Mr Jeffrey.

serve to explain the origin of the two different gallons. But the substitution of an original standard, derived from an object of definite magnitude, exterior to the human person, seems to have been reserved for the days of the French Revolution, though it has since been adopted, in an improved form, by the introduction of a foot equal to $\frac{12}{38}$ of the pendulum vibrating seconds as a representative of the customary foot of the kingdom of Denmark. (*Journal R. I.* 1821, *Astr. Coll.* N. V.)

The Royal Society, under the presidency of Mr Folkes, made some very accurate comparisons of the English, and French, and old Roman standards, which are recorded in the *Philosophical Transactions* for 1736, 1742, and 1743; and George Graham, the watchmaker, determined, at the same time, the correct length of the pendulum vibrating seconds to be 39.130 inches, but the standard, with which he compared it, requiring some reduction, it was afterwards ascertained, that the length, as derived from these experiments, ought to have been more nearly 39.14 inches.

A Committee of the House of Commons was appointed in 1758, of which Lord Carysfort was chairman; their Report contains some important information respecting the standards then in use. They found that the customary ale and beer gallon of the Excise was estimated at 282 cubical inches, while the legal wine gallon of the Exchequer was computed at only 231, though the only existing standard of the wine gallon, in 1688, which was kept at Guildhall, contained no more than 224 cubical inches; they suggested the adoption of this smaller gallon for the legal standard, perhaps as being more favourable to the revenue, though the gallon of 231 inches had been previously legalised by the act of the fifth of Queen Anne; and they employed the well known Mr Bird to prepare two standards, which were to be exact copies of that which was made by Graham for the Royal Society in 1742, from a very careful comparison of the various yards and ells of Henry the Seventh and Elizabeth, which were kept in the Exchequer. One of these copies was marked "Standard Yard, 1758," and was presented by the Committee to the House with the intention that it should be adopted as the legal standard; the other was made "with cheeks," for common use, and proposed to be kept in the Exchequer.

A subsequent Report of a Committee, appointed in 1759, consists principally of proposals for some legislative regulations, tending to facilitate the equalisation of weights and measures by the establishment of proper methods of checking and authorising the standards to be employed. In 1765, two bills were brought into the House of Commons by Lord Carysfort, in conformity with the reports of the Committees; but, from some accidental circumstances, they were not passed into laws.

Another Committee was appointed in 1790; but no minutes of their proceedings have been recorded. In 1814, however, a very important Report was presented to the House by a new Committee, who had called upon Dr W. Hyde Wollaston and Professor Playfair for their opinions on the subject; and it was principally in consequence of these examinations that the Committee stated that the length of the pendulum vibrating seconds had been ascertained to be 39.13047 inches, and that the metre of platina measured, at the temperature of 55°, 39.3828 English inches, representing, at 32°, the ten millionth part of the quadrant of the meridian; they remarked, with great truth, that, although in theory, the original standard of weight is best derived from the measure of capacity, yet, in common practice, it will generally be found more convenient to reverse this order; and they recommended, upon the suggestion of Dr Wollaston, that a gallon, containing ten pounds of pure water, should be adopted as a substitute for the ale and corn gallons, which had become different rather from accident than from any direct legislative authority, containing the one a little more than ten pounds, the other a little less, though the standards of the latter were extremely discordant among themselves. It seems to have been intended to abolish the wine gallon, which is also that of the apothecaries; though it was recommended to retain the use of the Troy Weight of the goldsmiths employed also by the apothecaries. It had before been observed, that twelve wine gallons of distilled water weighed exactly 100 pounds Avoirdupois; but Dr Wollaston's proposal, to make an ale gallon of exactly ten pounds, afforded a greater facility in the operation of adjusting the measure, since it is not very easy to divide 100 pounds into twelve equal parts, with the weights in common use.

Some very important experiments on weights and measures had been made, a little before the date of this Committee, by Sir George Shuckburgh Evelyn, who had published an elaborate paper on the subject in the *Philosophical Transactions* for 1798; and by the ingenious Mr Whitehurst, who obtained the length of the pendulum by measuring the difference of two lengths affording vibrations of different frequency. There were still some minute discordancies between the various measurements which appeared to be of the highest authority; and some particulars in the Report of the Committee of 1814 are manifestly erroneous; thus the weight of a cubic foot of water is stated, from a mistake in computation, to be 1000 ounces at $56\frac{1}{2}$° of Fahrenheit, while, in fact, it is less than this even at 39°, the maximum of density; and again, the customary length of the English foot, which has always been adjusted at the ordinary temperature of the atmosphere, and rather at that of the summer than of the winter, as, for example, in the great trigonometrical operations of General Roy and his successors, at 62° of Fahrenheit, was, in the experiments, copied by the Committee from Pictet, compared with the French standard, which was intended to be employed at the freezing point of water, without any correction for this diversity; though Dr Young had long before pointed out the omission both in the *Journals of the Royal Institution* and elsewhere, and had computed the true length of the metre according to these operations of Professor Pictet, confirmed by some earlier ones of Bird, Maskelyne, and Lalande, to be 39.3710 English inches, instead of 39.3828.

In order, therefore, to remove any doubt which might still be reasonably entertained on the subject, Mr Davies Gilbert moved the House of Commons, in the year 1816, to present an humble address to

the Prince Regent, praying that he would give direction, that proper measures should be taken for ascertaining the length of the pendulum vibrating seconds, and for comparing the French and English standards with each other. In consequence of this address, the Astronomer Royal was in the first instance directed to perform the necessary operations; and, upon his asking for some further assistance, the President and Council of the Royal Society were requested to appoint a Committee to cooperate with him. This Committee consisted, besides the President and Secretaries, of the late Sir Charles Blagden, Mr Gilbert, Dr Wollaston, Dr Young, Captain Kater, General Mudge, Mr Brown, Mr Rennie, and Mr Troughton. They began by discussing the several modes of making the requisite experiments which occurred to the different members, and it was resolved, that as many of these methods, as were preferred by each of them, should be separately carried into execution, in order to obtain collateral determinations of the required length. Mr Pond pursued the method of the French astronomers, and obtained some very satisfactory results, with an apparatus such as they had employed; Dr Young proposed a method derived from that of Whitehurst, and very perfect in theory, but somewhat complicated, and which has never yet been practically executed; Captain Kater invented, with great ingenuity, and employed, with great mechanical skill, an apparatus which does as much credit to his talents in the arrangement as to his perseverance in the experiments which he performed with it, and the accuracy of his determinations has been fully appreciated by mathematicians and practical astronomers throughout the world; and his operations have been and are still about to be repeated by many observers in different countries. Captain Kater's apparatus has been fully described in the Article PENDULUM of this *Supplement*; it owes no inconsiderable part of its advantage to the property subsequently demonstrated by Laplace, that, even if the opposite knife edges were considerably blunted and rounded off, supposing them to be equally affected, the distance between them would still afford the true measure of the length of the pendulum, without any further correction for the change of the axis of motion. It has also been demonstrated in this country, by means of the experiments of Chladni on the elasticity of metals, that the temporary change of form, depending on the compression of the steel edge, would be too inconsiderable to produce any sensible alteration of the length in question.

The object of Dr Young's apparatus was, to obtain two or more fine lines, traced at different parts of a scale, which should exhibit between them a certain determinate portion of the length of a pendulum vibrating seconds. He apprehended that the accurate determination of the form and direction of the knife edges, and the measurement of the distance between any such edges, which was necessary in the method proposed by Prony, as well as in that which was subsequently invented by Captain Kater, would require more skill and delicacy in the execution and the observation, than could be expected from any common workman or experimenter; and though Captain Kater, by his extreme care in combating every source of error, has, in point of fact, apparently obviated all these difficulties, yet it cannot be expected that so rare a combination of qualifications should again be found, in case of a repetition of the experiments, and Dr Young's apparatus may still, at some future time, be employed with advantage, at least for a collateral check upon the results.

The obstacles which prevented the completion of the observations which were made for some time with this apparatus at Greenwich, was the difficulty of obtaining a scapement so delicate as to count the number of vibrations, without sensibly interfering with their frequency. A very ingenious clockmaker was employed to furnish a scapement, of which the intention was to strike the pendulum slightly and instantaneously at the lowest point of its vibration, and then to recoil from it, so that even a considerable impulse might have little or no effect in altering the rate of the pendulum; but it was in fact observed, upon comparison with the clocks of the observatory, that the vibrations in larger arcs were more frequent than those which were performed in smaller; so that the scapement must have exerted a very considerable influence on the time of every vibration. It was therefore found necessary to abandon this method of making the experiment; but there would be no difficulty in conducting it very satisfactorily by means of a journeyman clock, with a wooden or brass pendulum, capable of having its length altered, so as to become comparable with the vibrations of Dr Young's pendulum in its different states; and it might even be found sufficient to observe the pendulum, with the same scapement, so altered as not to give any impulse whatever, but merely to reckon the vibrations by means of the detent, during the spontaneous vibrations of the pendulum, which, on account of its great weight, would be continued for a considerable time in consequence of the first impulse, taking care that the detent should be struck exactly at the middle of the vibration, and that it should rebound in some measure from the pendulum at the moment of contact.

Before any attempt was made to introduce any legislative regulations upon the foundation of the various scientific experiments, which had been so accurately and satisfactorily conducted, it was thought advisable by his Majesty's Ministers that the subject at large should be submitted to the deliberate consideration of some competent persons, who might discuss it more minutely than could be done with convenience before a Committee of either House of Parliament; and that a commission should be appointed for this purpose by a writ of the Privy Seal. The commissioners thus nominated in 1818 were the late Sir Joseph Banks, Sir George Clerk, Mr Davies Gilbert, Dr W. Hyde Wollaston, Dr Thomas Young, and Captain Henry Kater. Some further operations for the comparison of the existing standards of length were undertaken by Captain Kater; Dr Wollaston examined some of the authorised measures of capacity, and Dr Young offered his services as secretary to the committee, with the assistance of a clerk who had studied the law, while Sir George Clerk and Mr Gilbert were employed in

preparations for carrying into effect, in their legislative capacity, such regulations as the commissioners at large might agree to propose. The first occupation of the clerk was to make copious extracts from the statutes at large, by means of which Dr Young drew up an abstract of the present state of the laws relating to weights and measures, and afterwards to select from the *Agricultural Reports* of the different counties such materials, as afforded a glossary of all the terms employed in any part of Great Britain for denominating the irregular weights or measures, which have acquired a local currency in agricultural or other commercial transactions.

After this sketch of the previous history of the subject, we may now proceed to extract from the *Reports of the Commissioners*, and from the bills founded on them, such statements as may either serve in the place of canons for the regulation of weights and measures in general, or as documents respecting the actual value of the various standards possessing the highest degree of authenticity; and this article cannot be more properly concluded than by subjoining some further comparative tables of the standards of measures and weights adopted by different countries and at different periods.

First Report.—" I. Upon a deliberate consideration of the whole of the system at present existing, we are impressed with a sense of the great difficulty of effecting any radical changes, to so considerable an extent as might in some respects be desirable; and we, therefore, wish to proceed with great caution, in the suggestions which we shall venture to propose.

" II. With respect to the actual magnitude of the standards of length, it does not appear to us, that there can be any sufficient reason for altering those which are at present generally employed. There is no practical advantage in having a quantity commensurable to any original quantity existing, or which may be imagined to exist, in nature, except as affording some little encouragement to its common adoption by neighbouring nations. But it is scarcely possible that the departure from a standard, once universally established in a great country, should not produce much more labour and inconvenience in its internal relations, than it could ever be expected to save in the operations of foreign commerce and correspondence, which always are, and always must be, conducted by persons to whom the difficulty of calculation is comparatively inconsiderable, and who are also remunerated for their trouble, either by the profits of their commercial concerns, or by the credit of their scientific acquirements.

" III. The subdivisions of weights and measures at present employed in this country, appear to be far more convenient for practical purposes than the decimal scale, which might perhaps be preferred by some persons for making calculations with quantities already determined. But the power of expressing a third, a fourth, and a sixth of a foot in inches, without a fraction, is a peculiar advantage in the duodecimal scale; and, for the operation of weighing and measuring capacities, the continual division by two renders it practicable to make up any given quantity, with the smallest possible number of standard weights or measures, and is far preferable in this respect to any decimal scale. We would therefore recommend, that all the multiples and subdivisions of the standard to be adopted should retain the same relative proportions to each other as are at present in general use.

" IV. The most authentic standards of length which are now in existence being found, upon a minute examination, to vary in a very slight degree from each other, although either of them might be preferred, without any difference that would become sensible in common cases; we beg leave to recommend, for the legal determination of the standard yard, that 'which was employed by General Roy, in the measurement of a base on Hounslow Heath, as a foundation for the trigonometrical operations that have been carried on by the Ordnance throughout the country, and a duplicate of which will probably be laid down on a standard scale, by the Committee of the Royal Society appointed for assisting the Astronomer Royal in the determination of the length of the pendulum;' the temperature being supposed to be 62 degrees of Fahrenheit, when the scale is employed.

" V. We propose also, upon the authority of the experiments made by the Committee of the Royal Society, that it should be declared, for the purpose of identifying or recovering the length of this standard, in case that it should ever be lost or impaired, that the length of a pendulum vibrating seconds of mean solar time in London, on the level of the sea, and in a vacuum, is '39.1372' inches of this scale; and that the length of the metre employed in France, as the 10,000,000th part of the quadrantal arc of the meridian, has been found equal to '39.3694' inches.

" VI. The definitions of measures of capacity are obviously capable of being immediately deduced from their relations to measures of length; but since the readiest practical method of ascertaining the magnitude of any measure of capacity is to weigh the quantity of water which it is capable of containing, it would, in our opinion, be advisable in this instance to invert the more natural order of proceeding, and to define the measures of capacity rather from the weight of the water they are capable of containing, than from their solid content in space. It will therefore be convenient to begin with the definition of the standard of weight, by declaring that 'nineteen cubic inches of distilled water, at the temperature of 50°,' must weigh exactly ten ounces Troy, or 4.800 grains; and that 7000 such grains make a pound avoirdupois; supposing, however, the cubic inches to relate to the measure of a portion of brass, adjusted by a standard scale of brass. This definition is deduced from some very accurate experiments of the late Sir George Shuckburgh on the weights and measures of Great Britain; but we propose at a future period to repeat such of them as appear to be the most important.

" VII. The definitions thus established are not calculated to introduce any variation from the existing standards of length and of weight, which may be considered as already sufficiently well ascertained.

But, with respect to the measure of capacity, it appears, from the *Report* contained in the Appendix (A), that the legal standards of the highest authority are considerably at variance with each other: the standard gallon, quart, and pint of Queen Elizabeth, which are kept in the Exchequer, having been also apparently employed, almost indiscriminately, for adjusting the measures both of corn and of beer; between which, however, a difference has gradually, and, as it may be supposed, unintentionally crept into the practice of the Excise; the ale gallon being understood to contain about four and a half *per cent.* more than the corn gallon, though we do not find any particular act of Parliament in which this excess is expressly recognised. We think it right to propose, that these measures should again be reduced to their original equality; and at the same time, on account of the great convenience which would be derived from the facility of determining a gallon and its parts, by the operation of weighing a certain quantity of water, amounting to an entire number of pounds and ounces without fractions, we venture strongly to recommend, that the standard ale and corn gallon should contain exactly ten pounds avoirdupois of distilled water, at 62° of Fahrenheit, being nearly equal to '277.2' cubic inches, and agreeing with the standard pint in the Exchequer, which is found to contain exactly twenty ounces of water.

"VIII. We presume that very little inconvenience would be felt by the public from the introduction of this gallon, in the place of the customary ale gallon of 282 cubic inches, and of the Winchester corn gallon, directed by a statute of King William to contain 269, and by some later statutes estimated at $272\frac{1}{4}$ cubic inches; especially when it is considered that the standards, by which the quart and pint beer measures used in London are habitually adjusted, do not at present differ in a sensible degree from the standard proposed to be rendered general. We apprehend, also, that the slight excess of the new bushel above the common corn measure would be of the less importance, as the customary measures, employed in different parts of Great Britain are almost universally larger than the legal Winchester bushel.

"IX. Upon the question of the propriety of abolishing altogether the use of the wine gallon, and establishing the new gallon of ten pounds, as the only standard for all purposes, we have not yet been able to obtain sufficient grounds for coming to a conclusive determination; we can only suggest, that there would be a manifest advantage in the identification of all measures of the same name, provided that the change could be made without practical inconvenience; but how far the inconvenience might be more felt than the advantage, we must leave to the wisdom of his Majesty's Government to decide." . . .

Dated "24th June 1819."

"Appendix (A).

The standards kept at the Exchequer, for the adjustment both of CORN and BEER measures, are a bushel, a gallon, and a quart, dated 1601, and a pint, dated 1602, all marked with an E and a Crown. They were examined by Sir George Clerk and Dr Wollaston, and the weight of Thames water which they held, at the temperature of 52°, was found as in the subjoined table. Now, since, according to Sir George Shuckburgh's experiments, a cubic inch of distilled water, at 60°, weighs $252\frac{1}{2}$ grains, the specific gravity of the water being to that of distilled water as 1.00060 to 1, and the apparent specific gravity of distilled water, in a vessel of brass at 52°, being to that of water at 62° as 1.00046 to 1, it follows that the apparent specific gravity of the water employed was 1.00106, and that an ounce avoirdupois corresponded to 1.731 cubic inches. Hence we obtain the contents of the measures in cubic inches, which are compared, in the table, with the more direct measurement of Mr Bird and Mr Harris, reported to the House of Commons in 1758.

	Oz. Avoir.	Cub. In.		Gallon.	Rep. 1758.
Pint	20.00	34.6	$(\times 8 =)$	276.9	34.8
Quart	40.35	69.8	$(\times 4 =)$	279.3	70.0
Gallon	156.25	270.4	$(=)$	270.4	271.0
Bushel	1229.85	2128.9	$(\times \frac{1}{8} =)$	266.1	2124.0

"The Exchequer standard WINE gallon is dated 1707, and was found to contain 133·4 ounces, answering to 230.9 cubic inches. An experiment of Dr Wollaston and Mr Carr, in 1814, gave 230.8, the mean being 230.85; while the measurement of 1758 made it 231.2. A duplicate of this measure, and of the same date, is kept at Guildhall.

"Dr Wollaston and Mr Carr examined also the three other WINE gallons at Guildhall. The oldest of these seems to be the same that was measured by Halley and Flamsteed in 1688, and was said to contain 224 cubic inches; its actual capacity is 224.4. The wine gallon of 1773, which is in daily use for adjusting other measures, was probably in the first instance a correct copy of the Exchequer gallon, but has been reduced by a bruise, and by the wear of the brim, to 230.0 cubic inches, having lost $\frac{4}{5}$ of a cubic inch, or $\frac{1}{300}$ of its whole capacity. The wine gallon of 1798 contains 230.8 cubic inches.

"The Excise WINE gallon was found, by a similar experiment, to contain 230.1 cubic inches, having partaken of the progressive deficiency of the Guildhall gallon, from which it was derived."

Second Report. "We have examined, since our last *Report*, the relation of the best authenticated standards of length at present in existence, to the instruments employed for measuring the base on Hounslow Heath, and in the late trigonometrical operations. But we have very unexpectedly discovered that an error has been committed in the construction of some of those instruments: We are therefore obliged to recur to the originals which they were intended to represent, and we have found reason to prefer the Parliamentary standard executed by Bird in 1760, which we had not before received, both as being laid down in the most accurate manner, and as the best agreeing with the most extensive comparisons which have been hitherto executed by various observers, and circulated throughout Europe; and, in particular, with the scale employed by the late Sir George Shuckburgh.

"We have therefore now to propose, that this standard be considered as the foundation of all legal weights and measures, and that it be declared, that

the length of a pendulum vibrating seconds in a vacuum, on the level of the sea, in London, is 39.13929 inches, and that of the French metre 39.37079 inches, the English standard being employed at 62° of Fahrenheit."

Dated "13th July 1820."

Third Report. "The measurements which we have lately performed, upon the apparatus employed by the late Sir George Shuckburgh Evelyn, have enabled us to determine, with sufficient precision, the weight of a given bulk of water, with a view to the fixing the magnitude of the standard of weight; that of length being already determined by the experiments related in our former *Reports:* and we have found by the computations, which will be detailed in the Appendix, that the weight of a cubic inch of distilled water, at 62° of Fahrenheit, is '252.72' grains of the Parliamentary standard pound of 1758, supposing it to be weighed in a vacuum."

Appendix. The Commissioners having been furnished, by the kindness of the Honourable C. C. C. Jenkinson, with the apparatus employed by the late Sir George Shuckburgh Evelyn in the determination of the magnitude of the standard weights, and there being some doubt of the perfect accuracy of his method of measuring the capacity of the bodies employed, it was judged necessary to repeat that measurement with greater precautions; and the results of Captain Kater's experiments have afforded some slight corrections of the capacities in question.

"The sides of Sir George Shuckburgh's cube were found by Captain Kater equal to 4.98911, 4.98934, and 4.98935 inches, the diameter of the cylinder 3.99713, and its length 5.99600 inches; and the diameter of the sphere 6.00759 inches. Hence the content of the cube appears to be 124.1969 inches; that of the cylinder 75.2398; and that of the sphere 113.5264 inches of Bird's Parliamentary standard of 1760, recommended in the last *Report* of the Commissioners, or of the standard made by Troughton for Sir George Shuckburgh.

"The difference of the weight of the cube in the air at 62°, with the barometer at 29.0, and in water at 60.2°, was 31381.79 grains; and adding to this the weight of an equal bulk of the air at 62°, which is $\frac{1}{834}\cdot\frac{29}{30}$ of that of the water, or 36.26 grains, and subtracting from it $\frac{1}{8.5}$ of this, or 4.26 grains, the buoyancy of the brass weights, we obtain 31413.79 grains for the weight of the cube of water in a vacuum at 60.2°. Now this cube is less than the supposed measure, at the standard temperature of 62°, in the ratio of 1 to 1.0000567, on account of the contraction of the brass, and the water is denser than at the standard temperature, according to Mr Gilpin's experiments, in the ratio of .99998 to .99981, or of 1.00017 to 1; the whole correction, for the difference of 1.8°, being .0001133, or 3.55 grains, making 31410.24 for the weight of the cube of water in a vacuum at 62°; which, divided by 124.1969, gives 252.907 for the weight of a cubic inch, in Sir George Shuckburgh's grains.

"In the same manner, we obtain for the cylinder, which was weighed in air under the same circumstances, and in water at 60.5°, the difference being 19006.83 grains, the correction $\frac{1}{834}\cdot\frac{29}{30}\cdot\frac{7.5}{8.5}$ for the effect of buoyancy, amounting to 19.43 grains; and for the difference of temperature of the water and brass conjointly, the densities being .999955 and .999810, the correction .000145—.000047=.000095, or 1.80 grains, leaving +17.63 grains for the whole correction of the weight, as reduced to a vacuum at 62°, and making it 19024.46, which, divided by 75.2398, the content of the cylinder, affords us 252.851 for the cubic inch in a vacuum at 62°.

"The sphere was weighed in air at 67°, the barometer standing at 29.74; the correction for the buoyancy is here $\frac{7.5}{8.5}\cdot\frac{29.74}{30}\cdot\frac{1}{843}$, or, for 28673.51 grains, 29.72; while the temperature of 66° requires, for the difference between the expansion of brass and water, the addition of .00042—.000126, or .000294 of the whole, that is +8.43 grains, making the whole correction 38.15, and the weight in a vacuum 28711.66; which, divided by 113.5264, gives us 252.907, for the cubic inch in a vacuum.

"The mean of these three measures is 252.888, giving for the three errors, +.019,—.037, and +.019; and this mean, reduced to the Parliamentary standard, makes '252.722' grains, for the cubic inch of distilled water at 62°, weighed in a vacuum, or 252.456 in air, under the common circumstances of the atmosphere, when weights of brass are employed. In a vacuum, at the maximum of density, that is, at 39°, the weight of a true cubic inch will be 253 grains, and of a cubic decimetre 15440.* The proposed imperial gallon, of ten pounds, or 70000 grains of water, will contain very nearly 277.3 cubic inches, under common circumstances."

In conformity with these *Reports*, a bill was brought into the House of Commons, in 1822, by Sir George Clerk, and again, with a few alterations, in 1823, which appears to be drawn up with great care and judgment, and which comprehends a statement of the true ground of the proposed measures, and of the determinations which are intended for their bases.

"Whereas notwithstanding it is provided by the Great Charter, that there shall be but one Measure and one Weight throughout the realm, and by the Treaty of Union between England and Scotland, that the same weights and measures should be used throughout Great Britain as were then established in England, yet different weights and measures, some larger and some less, are still in use in various places throughout the United Kingdom of Great Britain and Ireland, and the true measure of the present

* It appears, however, from an official *Report* obligingly communicated to us by Dr Kelly, that the actual standard chiliogramme has been found to contain only 15433 English grains.

standards is not verily known, which is the cause of great confusion and of manifest frauds: Be it therefore enacted, THAT from and after the 1st January 1824, the straight line or distance between the centre of the two points in the gold studs in the straight brass rod, now in the custody of the Clerk of the House of Commons, whereon the words and figures 'Standard Yard, 1760,' are engraved, shall be, and the same is hereby declared to be, the original and genuine standard of that measure of length or linear extension called a yard; and that the same straight line or distance between the centres of the said two points in the said gold studs in the said brass rod, the brass being at the temperature of sixty two degrees by Fahrenheit's thermometer, shall be, and is hereby denominated the 'Imperial Standard Yard,' and shall be, and is hereby declared to be, the unit or only standard measure of extension wherefrom or whereby all other measures of extension whatsoever, whether the same be linear, superficial or solid, shall be derived, computed, and ascertained; and that all measures of length shall be taken in parts or multiples, or certain proportions of the said standard yard; and that one third part of the said standard yard shall be a foot, and the twelfth part of such foot shall be an inch; and that the pole or perch shall contain five such yards and a half, the furlong 220 such yards, and the mile 1760 such yards...

" And whereas it is expedient that the said standard yard, if lost, destroyed, defaced, or otherwise injured, should be restored of the same length by reference to some invariable natural standard: and whereas it has been ascertained, by the Commissioners appointed by his Majesty to inquire into the subject of weights and measures, that the said yard hereby declared to be the imperial standard yard, when compared with a pendulum vibrating seconds of mean time in the latitude of London, in a vacuum at the level of the sea, . . is in the proportion of thirty six inches to 39.1393; BE it therefore enacted and declared, That if at any time hereafter the said imperial standard yard shall be lost, or shall be in any manner destroyed, defaced, or otherwise injured, it shall and may be restored by making, under the direction of the Lord High Treasurer . . for the time being, a new standard yard, bearing the same proportion to such pendulum as aforesaid, as the said imperial standard yard bears to such pendulum.

" And 'whereas the Commissioners appointed by his Majesty to inquire into the subject of weights and measures have recommended that the standard brass weight of two pounds troy weight, made in the year 1758, and now in the custody of the Clerk of the House of Commons, shall be considered as authentic; be it enacted, That a brass weight equal to one half of the said brass weight of two pounds, gravitating in air (the barometer being at thirty inches, and the thermometer being at 62° by Fahrenheit's scale') 1822 [1823, be it further enacted, That from and after the 1st January 1824, the standard brass weight of one pound troy weight, made in the year 1758, now in the custody of the Clerk of the House of Commons], shall be, and the same is hereby declared to be, the original and genuine standard measure of weight; and that such brass weight . . shall be and is hereby denominated the Imperial Standard Troy Pound, and shall be, and the same is hereby declared to be, the unit or only standard measure of weight, from which all other weights shall be derived, computed, and ascertained; and that $\frac{1}{12}$ of the said troy pound shall be an ounce; and that $\frac{1}{20}$ of such ounce shall be a penny weight; and that $\frac{1}{24}$ of such penny weight shall be a grain; so that 5760 such grains shall be a troy pound; and that 7000 such grains shall be, and are hereby declared to be, a pound avoirdupois; and that $\frac{1}{16}$ of the said pound avoirdupois shall be an ounce avoirdupois; and that $\frac{1}{16}$ of such ounce shall be a dram.

" And whereas it is expedient, that the said standard troy pound, if lost, destroyed, defaced, or otherwise injured, should be restored of the same weight, by reference to some invariable natural standard; and whereas it has been ascertained, by the Commissioners appointed by his Majesty to inquire into the subject of weights and measures, that a cubic inch of distilled water in a vacuum, weighed by brass weights, also in a vacuum, at the temperature of 62° of Fahrenheit's thermometer, is equal to '252.72,' 1822 [1823, 252.724], grains, of which as aforesaid, the imperial standard troy pound contains 5760; BE it therefore enacted, That if at any time hereafter the said imperial standard troy pound shall be lost . . it shall and may be restored, . . by making, under the directions of the Lord High Treasurer . . a new standard . ." determined according to this proportion.

" And be it further enacted, That the standard measure of capacity, as well for liquids as for dry goods not measured by heaped measure, shall be the gallon, containing ten pounds avoirdupois weight of distilled water, weighed in air, at the temperature of sixty two degrees of Fahrenheit's thermometer, the barometer being at thirty inches; and that a measure shall be forthwith made of brass, of such contents as aforesaid, .. and such brass measure shall be, and is hereby declared to be, the imperial standard gallon, and shall be, and is hereby declared to be, the unit and only standard measure of capacity, from which all other measures of capacity to be used, as well for wine, beer, ale, spirits, and all sorts of liquids, as for dry goods not measured by heaped measure, shall be derived, computed, and ascertained; and that all measures shall be taken in parts or multiples, or certain proportions of the said imperial standard gallon; and that the quart shall be the fourth part of such standard gallon, and the pint shall be one eighth of such standard gallon; and that two such gallons shall be a peck, and eight such gallons shall be a bushel, and eight such bushels a quarter of corn or other dry goods, not measured by heaped measure.

" And be it further enacted, That the standard measure of capacity for coals, culm, lime, fish, potatoes, or fruit, and all other goods and things commonly sold by heaped measure, shall be the aforesaid bushel, containing eighty pounds avoirdupois of water as aforesaid, the same being made round with a plain and even bottom, and being $19\frac{1}{2}$ inches from outside to outside of such standard measure as aforesaid.

" And be it further enacted, That in making use of such bushel, all coals, and other goods and things commonly sold by heaped measure, shall be duly

heaped up in such bushel in the form of a cone, such cone to be of the height of at least six inches, and the outside of the bushel to be the extremity of the base of such cone; and that three such bushels shall be a sack, and that twelve such sacks shall be a chaldron." . .

"Provided always, and be it enacted, That in all cases of dispute respecting the correctness of any measure of capacity, arising in a place where recourse cannot conveniently be had to any of the aforesaid verified copies or models of the standard measures of capacity, it shall and may be lawful to and for any Justice of the Peace or Magistrate having jurisdiction in such place, to ascertain the content of such measure of capacity by direct reference to the weight of pure or rain water which such measure is capable of containing; ten pounds avoirdupois weight of such water, at the temperature of 62° by Fahrenheit's thermometer, being the standard gallon ascertained by this act, the same being in bulk equal to '277.276' 1822 [1823, 277.274] cubic inches, and so in proportion for all parts or multiples of a gallon."

The slight discordance between the numbers of the two successive years depends merely on the adoption of a standard troy pound, better authenticated than the two pound weight particularly employed by Sir George Shuckburgh, which was finally preferred both as representing a unit, and as being more simple in its form than the two pound weight.

Table of Various Measures.

From Folkes, Raper, Shuckburgh, Vega, Hutton's Ozanum, Cavallo, and others. Young's *Nat. Phil.* II. 152, 150.

Ancient Measures.

	E. F.	
Arabian foot	1.095	H.
Babylonian foot	1.144 1.135	H.
Drusian foot	1.090	H.
Egyptian "foot"	1.421	
stadium	730.8	H.
Greek foot	1.009	H.
	1.006 1.007	Folkes. = $1\frac{1}{24}$ Roman f.
	1.007	C.
phyleterian f.	1.167	H.
Hebrew foot	1.212	H.
cubit	1.817	H.
sacred cubit	2.002	H.
great cubit = 6 common cubits		H.
Macedonian foot	1.160	H.
Natural foot	.814	H.
Ptolemaic = Greek foot		H.
Roman foot	.970	Bernard.
	.967	Picard and Greaves, H.
	.966 .967	Folkes.
	.970	before Titus, Raper.
	.965	after Titus, Raper.
Roman, foot	.9672	from rules, Sh.
	.9681	from buildings, Sh.
	.9696	from a stone, Sh.
Roman mile of Pliny	4840.5	C.
of Strabo	4903.	C.
Sicilian foot of Archimedes	.730	H.

Modern Measures.

Altdorf, foot	.775	H.
Amsterdam, foot	.927	H.
	.930	C.
	.931	Howard on Lazarettos.
ell	2.233	C.
Ancona, foot	1.282	H.
Antwerp, foot	.940	H.
Aquileia, foot	1.128	H.
Arles, foot	.888	H.
Augsburg, foot	.972	H.
Austria. See Vienna.		
Avignon = Arles.		
Barcelona, foot	.992	H.
Basle, foot	.944	H.
Bavarian foot	.968	Beigel. See Munich.
Bergamo, foot	1.431	H.
Berlin, foot	.992	H.
Bern, foot	.962	Howard.
Besançon, foot	1.015	H.
Bologna, foot	1.244	H.
	1.250	C.
Bourg en Bresse, foot	1.030	H.
Brabant ell, in Germany	2.268	V.
Bremen, foot	.955	H.
Brescia, foot	1.560	H.
braccio	2.092	C.
Breslau, foot	1.125	H.
Bruges, foot	.749	H.
Brussels, foot	.902	H.
	.954	V.
greater ell	1.278	V.
lesser ell	2.245	V.
Castilian vara	2.746	C.
Chambery, foot	1.107	H.
China, mathematical foot	1.127	H.
imperial foot	1.051	H.
	1.050	C.
li	606.	C.
	1600.	Q. *Rev.* vi.
Cologne, foot	.903	H.
Constantinople, foot	2.195	H.
	1.165	H.
Copenhagen, foot. See Denmark	1.049	H.
Cracau, foot	1.169	H. V.
greater ell	2.024	V.
smaller ell	1.855	V.
Dantzic, foot	.923	H.
Dauphiné, foot	1.119	H.
Delft, foot	.547	H.
Denmark, old foot	1.047	H.
new foot	1.036	
Dijon, foot	1.030	H.
Dordrecht, foot	.771	H.

	E. F.	
Dresden, foot	.929	Wolfe, *Ph. Tr.* 1769. V.
ell=2 feet	1.857	V.
Edinburgh. See Scotland.		
Ferrara, foot	1.317	H.
Florence, foot	.995	H.
braccio	1.900 1.910	C.
barilo of wine weighs 140 Fl. pounds=20 fiaschi.		
cogno=10 barili.		
rubbio of wheat 640 Roman pounds.		
Franche Comté, foot	1.172	H.
Frankfort=Hamburg		H.
Genoa, palm	.812	H.
	.800 .817	C.
carna	7.300	C.
Geneva, foot	1.919	H.
German, mile=$\frac{1}{15}$ degree.		
Grenoble=Dauphiné		H.
Halle, foot	.977	H.
Hamburg, foot	.933	H.
Heidelberg, foot	.903	H.
Inspruck, foot	1.101	H.
Ireland, perch 7 yards.		
acre, 7840 sq. y. E.		
Italy, old common mile	5299.	
Leghorn, foot	.992	H.
Leipzig, foot	1.034	H.
ell	1.833	H.
Leyden, foot	1,023	H.
Liege, foot	.944	H.
Lisbon, foot	.952	H.
Lombardy, mile=$\frac{1}{67}$ degree.		
Lucca, braccio	1.958	C.
Lyons=Dauphiné.		
Madrid, foot	.915	H.
	.918	Howard.
vara	3.263	C.
	3.285	Laconda-mine, from Juan.
Maestricht, foot	.916	H.
Malta, palm	.915	H.
Mantua, brasso	1.521	H.
Mantuan braccio=Brescian		C.
Marseilles, foot	.814	H.
Mechlin, foot	.753	H.
Mentz, foot	.988	H.
Milan, decimal foot	.855	H.
aliprand foot	1.426	H.
braccio	1.725	C.
Modena, foot	2.081	H.
Monaco, foot	.771	H.
Montpellier, pan	.777	H.
Moravian foot	971	V.
ell	2.594	V.
Moscow, foot	.928	H.
Munich, foot	.947	H.
Naples, palm	.861 .859	H. C.
canna	6.908	C.
mile="$\frac{1}{30}$ degree," rather $\frac{1}{60}$.		

	E. F.	
Naples, barilo of wine=60 carafe.		
carafa=$\frac{2}{3}$ Parisian pint.		
botto=12 barilli.		
carro=2 botti.		
tumulo of wheat 3 cubic palms, or 40 rotoli.		
Nuremberg, town foot	.996 .997	H. V.
country foot	.907	H.
artillery foot	.961	V.
ell	2.166	V.
Padua, foot	1.406	H
Palermo, foot	.747	H.
Paris, old foot	1.066 1.06578=$\frac{81}{76}$	H. Y.
point	.0148	E. i.
line	.0888, or $\frac{8}{90}$	E. i.

ell=44 Fr. i. or=43.9 V.
sonde 5 Fr. feet=$\frac{8}{9}$ E. fathom.
toise 6 Fr. feet=76.736 E. i.
perche 18 Fr. feet.
perche royale 22 Fr. feet
league 2282 toises=$\frac{1}{25}$°.
square foot or inch 1.13581 E.
cubic foot or inch 1.21061 E.
arpent, 100 square perches, about $\frac{5}{6}$ E. acre: mesure royale, about $\frac{5}{4}$.
pint, 48 cubic inches Dict. Acad.=58.11 English.
litron 74.375 c. i. E.
boisseau 1190,=16 litrons.
minot=2 boisseaux, nearly a bushel English =2380 c. i. E.
mine= 2 minots=4760 c. i. E.
septier=2 mines=9520 c. i. E.=1.56 hecatol. Annuaire: for oats double.
muids=12 septiers.
ton of shipping, 42 cubic feet.
metre 3.07844 f. Fr.=3.281 f. E.=39.3708 i. E. Kater. Hence, correcting the unclassical orthography of the new school:

millimetre	.03937	E. i.
centimetre	.39371	
decimetre	3.93708	
metre	39.37079	
decametre	393.70790	
hecatometre	3937.07900	
chiliometre	39370.79000	
myriometre	393707.90000	

8 chiliometres are nearly 5 miles.
1 inch is .0254^{m}; 1000 f. nearly 305^{m}.

1 centimetre=	.39371	E. i.
2	.78742	
3	1.18113	
4	1.57483	
5	1.96854	
6	2.36225	
7	2.75596	
8	3.14966	
9	3.54337	
10	3.93708	

1 square centimetre=.155006 sq. i.
are, or square decametre 3.95 E. perches.
hecatare 2 acres, 1 r. 35.4 p.
millilitre .06103 c. i. E.

Paris, centilitre .61028
decilitre 6.10279
litre, or cubic decimetre 61.02790
decalitre 610.27900
hecatolitre 6102.79000
chiliolitre 61027.90000
myriolitre 610279.00000
a litre is nearly $2\frac{1}{8}$ wine pints; a chiliolitre 1 tun $12\frac{3}{4}$ wine gallons.
decistere, of fire wood 3.5317 c. f. E.
stere, or cubic metre 35.3171

E. F.

Parma, foot . 1.869 E. f. H.
braccio . 2.242 C.
Pavia, foot . 1.540 H.
Piemont, old mile=$1\frac{1}{2}$ m. E.
Placentia=Parma. C.
Prague, foot { .987 H. / .972 V. }
ell . 1.948 V.
Provence=Marseilles.
Rhinland foot . 1.030 V. Eytelwein.
Riga=Hamburg.
Rome, palm . .733 H.
foot . .966 Folkes.
oncia $\frac{1}{12}$ f. .0805 F.
deto $\frac{1}{16}$ f. .0604 F.
palmo . .2515 F.
palmo di architettura .7325 F.
canna di architettura 7.325 F.
staiolo . 4.212 F.
braccio dei mercanti { 2.7876 F. "4 palms." / 2.856 C. }
canna dei mercanti 6.5365 F. "8 palms."
braccio di tessitor di tela } 2.0868 F.
braccio di architettura 2.561 C.
mile $\frac{1}{75}$ degree
Rouen=Paris. C.
Russian arschin { 2.3333 *Ph. M.* XIX. / 2.3625 C. }
rerschock $\frac{1}{16}$ a. .1458
werst 3508.
Savoy=Chambery. H.
Scotland, ell, 37 Sc. i.=37.2 E. i.=3.100
fall, 6 e. 223.2 18.600
furlong 744.
mile 5952.
link 8.93
chain 892.8
long rood 1339.2
acre 55353.6 sq. f. E.=1.27 acre E.
gill 6.462 c. i. E.
mutchkin 25.85
choppin 51.7
pint 103.4
quart 206.8
gallon 827.23
hogshead 13235.7, 16 g.
gallon of the Union 799.=$\frac{1}{12}$ E. barrel.
lippie, or feed 200.345
pint jug of Stirling 103.72 c. i. E.

Scotland, pint jug of Aberdeen 105.30
firlot of Linlithgow, for bear 3205.5=31 pints.
—— for wheat { 2150. / 2197.3 }
—— of Edinburgh, $1\frac{1}{2}$ *per cent.* greater.

E. F.

Seville=Barcelona. H.
vara . 2.760 C.
Sienna, foot . 1.239 H.
Spain, league=4 miles E.
Stettin, foot . 1.224 H.
Stockholm, foot . 1.073 H.
canne 106 c. i. Sw.
Strasburg, town foot .956 H.
country foot .969 H.
Toledo=Madrid. H.
Trent, foot . 1.201 H.
Trieste, ell for woollens 2.220 H.
silk 2.107 H.
Turin, foot . { 1.676 H. / 1.681 C. }
ras . 1.958 C.
trabuco . 10.085 C.
Tuscany, mile . 5329.
See Florence.
Tyrol, foot . 1.096 V.
ell . 2.639 V.
Valadolid, foot . .908 H.
Venice, foot { 1.137 H. / 1.140 Bernard, Howard, V. / 1.167 C. }
braccio of silk 2.108 C.
ell . 2.089 V.
braccio of cloth 2.250 C.
mile=$\frac{1}{66}$ or $\frac{1}{67}$ degree.
moggio of wheat weighs 528 V. pounds.
Verona, foot . 1.117 H.
Vicenza, foot . 1.136 H.
Vienna, foot . 1.036 H.
1.037 Howard, C. V.
ell . 2.557 V.
post mile 24888. V.
yoke of land, 1600 square fathoms.
metz, or bushel, 1.9471 c. f. of Vienna.
eimer=40 kannen=1.792 c. f. V.
fass=10 eimer. Vega.
Vienne, Dauphiné, foot 1.058 E. f. H.
Ulm, foot . .826 H.
Urbino, foot . . 1.162 H.
Utrecht, foot . .741 H.
Warsaw, foot . . 1.169 H.
Wesel=Dordrecht H.
Zurich, foot . { .979 H. / .989 *Ph. M.* VIII. }

TABLE OF VARIOUS WEIGHTS.

Ancient Weights, H.

E. Gr.

Attic obolus { 8.2 Christiani. / 9.1 Arbuthnot. }

	E. Gr.
Attic drachma	51.9 Chr. / 54.6 Arb.
lesser mina	3892. 75 dr. Chr.
greater mina	5189. 100 dr. Chr. / 5464. Arb.
medical mina	6994. Arb.
talent=60 minae=$\frac{1}{2}$ cwt. E.	
Old Greek drachm	146.5 E. gr. Arb. / 62.5=Roman denarius, Arb.
Old Greek mina	6425. Arb.
Egyptian mina	8326.
Ptolemaic mina of Cleopatra	8985.
Alexandrian mina of Dioscorides	9992.
Roman denarius	51.9 Chr. $\frac{1}{8}$ oz. / 62.5 Arb. $\frac{1}{7}$ oz.
ounce	415.1 Chr. / 437.2 Arb.=av. oz.
pound of 10 oz.	4150. Chr.
12 oz.	4981. Chr. / 5246. Arb.

Modern Weights.

From Hutton, Cavallo, Vega, and others.

Pounds.	E. grains.
Aleppo, rotolo	30985. H.
Alexandria	6159. H.
Alicant	6909. H.
Amsterdam	7461. H.
Amsterdam, commercial pound, 7636.= 10280 ases=494.048 grammes. Coquebert,=493.93 grm. Vega. Troy pound, 7602. E. gr. adjusted at Brussels, 1553,= 10240 ases,=491.96 grm. Coq. =492.0044 grm. V. stone 16 pounds, ounce $\frac{1}{16}$ pound, drop $\frac{1}{16}$ ounce. Apothecaries' pound 369 grm. V. See Brabant.	
Antwerp	7048 E. gr. H.
Avignon	6217 H.
Basle	7713 H.
Bayonne	7461 H.
Bergamo	4664 H. / 11660 H.
Bergen	7833 H.
Berlin	7232 Eytelw.
A cubic foot Fr. of water weighing 65.9368.	
Bern	6722.
Bilboa=Bayonne	H.
Bois le Duc	1705. H.
Bourdeaux=Bayonne.	
Bourg	7074. H.
Brabant pound of Amsterdam	7249.=469.12 grm. Coq.
Brescia	4497. H.
Brussels heavy pound=Troys	V.
light pound	7201.=466.3 grm. V.

Pounds.	E. grains.
Cadiz	7038. H.
China, kin	9223. H. / 5802.=375.708 grm. Coq.
leang=$\frac{1}{10}$ kin	
tsien=$\frac{1}{10}$ leang	
Cologne	7220. H. / 7218. Eytelwein,
a c. f. Fr. of water weighing 66.0656.	7223.=467.74 grm. V.
grain, $\frac{1}{531}$ of the weight of a cubic inch Fr. of water, at 57°. *Studer in Gilb.* XI.	
Constantinople	7578. H.
Copenhagen	6941. H.
Cracau, commercial pound	6252. H. 404.85 grm. V.
mint mark	3071. 198.82 grm. V.
Damascus	25613. H.
Dantzic	6574. H.
Dresden	7210. 468.83 grm. V.
Dublin	7774. H.
Florence	5287. H.
ounce $\frac{1}{12}$ pound =24 denari of 24	(440.6) grains each.
France. See Paris.	
Geneva	8407. H.
Genoa	4426. H. / 6638. H.
=12 ounces. rotolo=18 ounces. rubo=25 pounds. cantaro=6 r. peso=5 cantari.	
Germany, apothecaries	5523. 357.66 grm. V.
Hamburg	7315. H.
Ireland. See Dublin.	
Königsberg	5968. H.
Leghorn	5146. H.
Leyden	7038. H.
Liege	7089. H.
Lille	6544. H.
Lisbon	7005. H.
London, Avoirdupois	7000. 453.61. grm. V.
Troy	5760. 373.14 grm. V.
Lucca	5273. H.
Lyons, silk	6946. H.
town weight	6432. H.
Madrid	6544. H.
Marseilles	6041. H.
Melun	4441. H.
Messina	4844. H.
Montpellier	6218. H.
Namur	7174. H.
Nancy	7038. H.
Naples	4952. H.
=12 oncie rotolo=33$\frac{1}{3}$ o. staro=10$\frac{1}{3}$ r. cantaro=100 r. oncia=30 trapesi. trapeso=20 acini.	
Nuremberg	7871. 509.78 grm. V.

Weights and Measures || Westmeath.

Pounds.	E. grains.
Paris	7561 H. or 7560=1.08 lb. av.
marc $\frac{1}{2}$ a pound	
ounce $\frac{1}{8}$ marc	
gros $\frac{1}{8}$ ounce	
denier $\frac{1}{3}$ gros	
grain $\frac{1}{24}$ denier=	.8203 gr. E.
milligramme	.0154 gr. E.
centigramme	.1543
decigramme	1.5433
gramme	15.4330, 18.827 gr. Fr.
decagramme	154.3300 5.65 dr. av.
hecatogramme	1543.3000
chiliogramme	15433.0000 2 lb.3 $\frac{1}{3}$ oz. av. 2.0429 lb. Fr.
myriogramme	154330.0000; according to Dr Kelly's experiments on the actual weights in use, but according to the English experiments, the gramme ought to weigh 15.4400 grains E.
quintal=10 myriogrammes	
millier=1000 chiliogrammes; about a ton.	
sous=5 grammes of copper	
franc=5 grammes of silver, with $\frac{1}{10}$ of copper.	
Prague, commercial pound,	7947. E. gr. 514.35 grm. V.
Revel	6574. H.
Riga	6149. H.
Rome	.5257. H.
=12 oncie	
oncia=8 dramme	
dramma=3 scrupoli	
scrupolo=2 oboli	
obolo=4 silique	
siliqua=12 grani.	
Rouen	7772. H.
Saragossa	4707. H.
Scotland, Troy pound, Dutch	7621.8
Trone pound $\frac{5}{4}$ Troy	9527.25
ounce	476.3
Seville=Cadiz.	
Smyrna	6544. H.
Stettin	6782. H.
Stockholm	9211. H.
Strasburg	7277. H.
Toulouse	6323. H.
Troys. See Amsterdam, Scotland.	
Turin	4940. H.
Tunis	7140. H.
Tyrol	8693. 562.92 grm. V.
Venice	4215. H. / 6827. H.
libra sottile of 12 ounces, 302.03 grm. V.	
common pound of 12 ounces, 358.1 grm. V.	
pound of 12 ounces, peso grosso, 468.17 grm. V.	
libra grossa, 477.49 grm. V.	
Verona	5374 V.
Vicenza	4676 H. / 6879 H.
Vienna, commercial pound	8648. 560.01 grm. V.
Apothecaries pound	420.01 grm. V.
Mint mark	280.64. grm. V.
carat of the jewellers	.206085 grm. V.

Apothecaries Grains of different Countries.

From Vega.

Austria	1.125=$\frac{9}{8}$
Bern	.956
France	.981
Genoa	.850
Germany	.958 / .959 Gilb.
Hanover	.978
Holland	.989
Naples	.860
Piemont	.824
Portugal	.864
Rome	.909
Spain	.925
Sweden	.955
Venice	.809.

(A. L.)

Boundaries. WESTMEATH, an inland county in the province of Leinster in Ireland, bounded on the north by Cavan, on the east by Meath or Eastmeath, on the south by King's County, on the north-west by Longford, and on the west by the river Shannon, which separates it from Roscommon. It extends from north to south 25 miles, and from east to west 24, and contains 592 English square miles, or 378,880 English acres. It is divided into 12 baronies and 62 parishes, the latter belonging to the Sees of Meath and Ardagh.

Extent.

Surface. The surface of this district is exceedingly diversified with wood, lakes, and streams, bogs, and rich grazing lands; in no part mountainous nor flat, but gently undulating or rising into hills of no great elevation, some of which are cultivated to their summits, and others covered with wood, presenting in several parts some of the finest scenery in Ireland. The rivers are the Shannon on the western boundary, which here expands into the noble lake called Lough Ree, full of wooded islands; the Inny, which has its source among some lakes on the north, and flowing south and south-west joins the Shannon, at Lough Ree, is a considerable stream which also spreads out into lakes in its course; and the Brosna, which rising in Lough Owell, passes into King's County. From this lake another stream also takes it rise, and flows in a direction opposite to that of the Brosna. The principal lakes are Loughs Leign, Iron, Derveragh, Hoyle or Owell, and Ennel, some of them surrounded by low wooded hills, and others by fertile and well cultivated fields. Most of the soil, lying upon limestone, yields very fine pastures.

Rivers.

Lakes.

Estates. Westmeath contains few large estates, but it abounds with gentlemen of moderate fortunes from L. 2000 to L. 3000 a year, most of whom are resi-

Westmeath || Westmoreland.

dent. The leases are commonly for 21 years and a life, though in some instances for 31 years and three lives. A great many fine long-horned cattle and long-woolled sheep occupy the grazing grounds, which extend over much of the best part of the district. Tillage is accordingly upon a limited scale, though more corn is raised than the inhabitants consume; and besides the crops common in other places, flax, hemp, and rape, are cultivated, with clover and turnips, the two latter, however, not generally.

Towns.

There are few towns here, and none of them large. The most considerable is Athlone, seated on both sides of the Shannon; so that part of it is in the county of Roscommon. Mullingar, the county town, is noted for its great fairs for horses and for wool. Mool-grenoguer, Kilbiggan and a few others, are very small places. Before the Union, the county, with the boroughs of Mullingar, Athlone, Kilbiggan, and the now miserable village of Fowre, sent ten members to Parliament; the number now is two for the county, and one for the town of Athlone. Notwithstanding its inland and central situation, Westmeath enjoys the benefit of extensive water communication by the Shannon on the west, and the Royal Canal from Dublin, which crosses it from east to west by Mullingar; the Grand Canal also passes near its northern boundary. Yet, as the linen manufacture is the only one which affords a surplus for exportation, its trade consists chiefly in the exchange of live stock and the raw produce of the land, for the commodities required for the consumption of its inhabitants. The land-owners here are almost all Protestants, but the rest of the population is chiefly Catholic.

Population.

In 1791, the number of inhabitants was computed to be 69,000; by the census of 1821, it was 128,042. The condition of the lower classes is better than in Meath, and some of the contiguous counties; they are not addicted to drinking, but industrious and provident. The women, who work a good deal out of doors, are singularly hardy. Mr Wakefield saw them four days after they had lain in, carrying into the fields their husbands' dinner. The people are nevertheless very superstitious, and under great subjection to their priests, who sometimes beat them, which they submit to without grumbling. The same author was informed that indulgences were sold in 1809, at a friary at Multifarnham in this county.

See the general works quoted under the former Irish counties. (A.)

Boundaries and Extent.

WESTMORELAND, one of the most northern English counties. It is separated from the sea shore by a narrow strip of the county of Lancaster, which bounds it on the south and south-west, as do Cumberland on the north and north-west, and Yorkshire on the east. It is of a very irregular shape. Its greatest length is 40, and its greatest breadth 35 miles; containing, by the best estimate, 763 square miles, or 490,320 British statute acres. It is divided into four wards, distinguished by the prefixes of East, Kendal, Lonsdale, and West, which are again divided into thirty parishes.

Population.

The population, according to the returns of 1821, amounted to 51,359, of whom 25,513 were males, and 25,846 females. The families were 10,438; of whom 5096 were chiefly employed in agriculture, 3801 in trade, manufactures, or handicraft, and 1541 were comprised in neither of those classes. The increase of inhabitants in the preceding ten years had been only 12 *per cent.* The density of population is much less than in any other county, being but one individual to nine acres and a half of land.

Face of the Country.

The greater part of the county consists of bleak and barren moors, and groups of lofty and naked mountains. The vallies between these mountains through which the rivers wind are of moderate fertility, and when well cultivated yield good crops of oats, and in some few instances of wheat and barley. The better parts of these vallies are appropriated to feed cattle or produce hay. The acreable value of the land, in the whole of this county, is much lower than that in any other part of England. According to the returns under the income-tax, the average annual rent and tithes together did not exceed 8s. 7d. *per* acre, being about half the average value of the rest of the kingdom. The romantic prospects, however, which are afforded by the contrast between the mountains and the lakes, more than repay the traveller for rambling at his leisure through the fine scenery. The lakes of Winandermere and Ulleswater are partly in this county, and those of Grasmere and Hause Water, with several smaller lakes, provincially called Tarns, wholly so. Besides the char (a fish almost peculiar to those lakes), trouts, pikes, perch, and eels, are taken abundantly in these waters.

Productions.

The cattle of Westmoreland are of the long-horned kind, and attain a large size when well fed; the butter they afford is highly valued, and supplies to some extent the markets of the metropolis. Large flocks of sheep are fed on the mountains, which yield a coarse wool; but by crossing the breed, the wool of late years has been much improved. Numbers of geese are fed on the moors, and these, with hams, form a part of the exports of the county. Westmoreland is nearly destitute of coals, and the metallic ores lie so deep, or are in such remote situations, that they are none of them worked. Slates, of the finest quality, are abundant, and large quantities of them are exported. Limestone is also very plentiful.

Manufactures.

The principal manufactures of the county are chiefly carried on at Kendal, a place early celebrated for woollen cloth, which bore its name. This manufacture, and that of linsey woolsey, as well as of coarse worsted stockings, is still continued, and recently considerable progress has been made in introducing the making of cotton goods.

Rivers.

The principal rivers are the Eden, the Lune, the Ken or Kent, and the Lowther, which are more remarkable for the beauties displayed on their borders, and for the abundance of fish they contain, than for any facilities they afford to intercourse. None of them are navigable, nor are there any artificial canals.

Representation in Parliament.

This county gives titles to two noble families, the Earls of Westmoreland and Lonsdale. Two members are returned to the House of Commons by the county, and two by the borough of Appleby, which, though small, is the capital of the county, and the place where the assizes and elections are held.

Westmoreland || Wexford.

The most remarkable seats of noblemen and gentlemen are the following: Lowther Castle, Lord Lonsdale; Appleby Castle, Lord Thanet; Abbot Hall, Christopher Wilson, Esq.; Mint House, J. H. Long, Esq.; Netherdale Hall, John Mounsey, Esq.; Brougham Hall, Henry Brougham, Esq.; Carlton Hall, Right Hon. Thomas Wallace.

The town of Kendal contains 8984 inhabitants, and Kirby Lonsdale 1643; no other town in the county has a population of 1500.

See Britton's *Beauties of England; England Delineated; Parliamentary Population Returns.*

(W. W.)

Boundaries. WEXFORD, a county in the province of Leinster in Ireland, having the county of Wicklow on the north, the sea on the east and south, and Waterford, Kilkenny, and Carlow, on the south-west and west; extends about 56 miles from north to south, and 32 from east to west, and contains 934 English square miles, or 597,760 English acres. It is divided into eight baronies, exclusive of the liberties of the town of Wexford, and 142 parishes, 140 of which belong to the diocese of Ferns, and two to that of Dublin. There are some inconsiderable islets on the south coast belonging to the county; the two Salters are the largest, neither of them having an area of a square mile.

Divisions.

Surface. On the north and north-west, on the confines of Wicklow and Carlow, this district is mountainous, and the same character applies generally to its western side. On the east, in the baronies of Forth and Bargie, it becomes less elevated, and here the soil, though light, is well cultivated and productive. In the other parts a cold stiff clay prevails, which, from the want of limestone, there being none in this county, has made little advance towards improvement. The Slaney, which flows through the middle of the district, from Newton Barry to Wexford, affords a perpetual variety of picturesque and romantic views among its wooded and winding banks; the stream here struggling through rocks, by which its channel is greatly contracted, and there expanding into broad and still lakes. The scenery around the bay of Wexford has been also much celebrated. Besides the Slaney, which is navigable to Enniscorthy, near the middle of the county, it has the Barrow, which separates it from Kilkenny on the west, by which large vessels reach the town of New Ross, situated near the junction of that river with the Nore. A great variety of fine timber trees, and some large myrtles, are found here, and the woodlands altogether are of considerable extent and value.

Estates and Farms. Wexford is divided into estates worth from L. 2000 to L. 10,000 a-year, and into farms of various sizes; but there is little of that minute division which is common in other parts of Ireland; nor are there any rich grazing farms. The rent, in 1808, was estimated at from 20s. to 25s. an Irish acre over all the county. Dairies, at which the principal article is butter, are numerous, but generally under bad management. The cows themselves are of a very inferior description; and the same character belongs to their sheep, which form a very inconsiderable part of the live stock. In their modes of cultivation, however, the farmers here are more advanced than in many other parts of the island. The baronies of Forth and Bargie have been long noted for their great crops of barley; beans too are cultivated with success, as well as clover and turnips; the drill system is common for potatoes, and preferred to every other method; and lime, though brought from a distance at a great expence, and also marl, are very extensively employed as manure. The tenantry, even including the cottars, are accordingly in a much better condition, industrious, provident, and many of them comparatively wealthy. Here, as in Cork and Waterford, whole fields are kept under furze, which, in this mild climate, is pretty much used as fuel. The bakers employ it for heating their ovens, of which a considerable number are employed, as a good deal of wheaten bread is consumed in these counties.

Towns. The towns are Wexford, the county town; Enniscorthy on the Slaney; New Ross on the Barrow; Gorey; and Newton Barry, the latter one of the pleasantest villages in Ireland. Wexford is a considerable town, situated on the large and beautiful harbour of the same name, but which is too shallow to admit vessels of great burden, and the passage into it is continually changing, owing to the sand brought down by the Slaney, which flows into it. Here there is a wooden bridge over an arm of the sea 2100 feet broad. The trade of this town, however, is not inconsiderable. It exports corn, chiefly to Liverpool; provisions which are brought down the Slaney from Enniscorthy; and also live stock. Enniscorthy and New Ross are also places of some trade, supplying the consumption of the surrounding country with their imports, and affording outlets for its raw produce. The linen manufacture, so general in Ireland, is almost unknown in Wexford; but that of cotton is carried on at Enniscorthy, where a good deal of coarse woollens are also made. Before the Union no fewer than eighteen members were returned to Parliament for this district; the county and the boroughs of Wexford, Enniscorthy, Gorey, New Ross, Fetherd, Bannow, Clonmines, and Taghmore, sending two each. Wexford and New Ross have now each one representative, and the county two. "This county," says Mr Wakefield, "is the only one in Ireland where the tenants have displayed the courage to act in opposition to their landlords" in voting for candidates; "but it is merely from a religious principle, as they have no other political system to support, than that which promotes the interest and success of the Catholic faith." The Catholic population, according to the same writer, is to the Protestant as ten to one, and most of the personal property, and part of the landed, is in the hands of the former. In 1791 the whole was computed to amount to 115,000, and by the census of 1821 it was 169,304. The baronies of Bargie and Forth are peopled by a distinct race, who are said to be descended from the adventurers who accompanied Strongbow to Ireland, and their manners and habits, which are different from those of the Irish around them, bear a strong resemblance to those of their Saxon forefathers.

Representation.

Population.

Friaries. There are friaries of the order of St Augustine at New Ross, Clonmines, and Wexford, the members

of which are supported by contributions levied upon the tenantry. This county took an active part in the Rebellion of 1798, and was the scene of some acts of savage cruelty perpetrated by both parties.

See the general works quoted under the Irish counties, and Frazer's *Statistical Survey of Wexford.*

(A.)

WHITAKER (JOHN), was born at Manchester about the year 1735. Of his parentage, and of his first steps in learning, we find no memorials; but he was sent at an early age to the University of Oxford, and in due time was elected a fellow of Corpus Christi College. He took the degree of M. A. in 1759, and that of B. D. in 1767. Here, we are informed, "his uncommon vigour of intellect at once displayed itself among his acquaintance; but, whilst his animated conversation drew many around him, a few were repelled from the circle by his impatience of contradiction (a failing which almost ever accompanies powers like his), and by the consciousness, it should seem, of their own inferiority." That his conversation must have displayed sufficient vivacity, and his temper sufficient warmth, may very easily be conceived; but through these lines of panegyric, it is impossible not to discern a strong ray of truth; namely, that, from the earliest period of his literary career, he was distinguished by a bold and dogmatical spirit, which could ill endure dissent or opposition. This may indeed be considered as his first and last characteristic; and although the zeal of a friend has, with some degree of dexterity, endeavoured to convert it into a topic of praise, by representing it as the ordinary mark of a superior mind, we are not very much inclined to regard it in the same light. The doctrine seems, indeed, to be of a somewhat dangerous tendency; to be calculated for misleading young candidates for literary honours, who may thus be induced to supply, by arrogance and dogmatism, what is wanting in sound learning and solid judgment. It may be asserted without much hazard of confutation, that this overweening and dogmatical spirit is at least as frequently the characteristic of those who possess but a very moderate stock of real merit; who have perhaps made no uncommon progress in any branch of science or literature, and yet consider themselves as entitled to decide all controversies, and to adjust all claims to intellectual distinction.

While Mr Whitaker was still a fellow of his college, he gave the first conspicuous proof of his abilities by the publication of *The History of Manchester.* Lond. 1771, 4to. The second volume followed in the year 1775; but although four books were originally promised, only two are thus completed; they embrace the Roman, British, and Saxon periods of the history. This work, which is perhaps the most remarkable of his publications, was immediately regarded as the production of no ordinary writer, but as more conspicuous for bold and ingenious speculation, than for cool and judicious discussion. Like the other works of the same author, it is written in a lively and rambling manner. His impatience and vivacity rendered him incapable of selecting his topics, and condensing his thoughts; and by adhering to his usual method of writing, a large book may be produced on almost any subject.

Before he had brought this work to a close, he published *The Genuine History of the Britons asserted.* Lond. 1772, 8vo. This volume is chiefly directed against the historical work of Mr Macpherson, better known as the foster-father of *Ossian;* and both publications have been considered by competent judges as adding very little to the real stock of information.

In the course of the following year we find him residing in the metropolis, and officiating as the morning preacher of Berkeley Chapel. For this appointment he was indebted to a Mr Hughes; but their connection was of a very short duration, for he was removed from his situation in less than two months. He thought proper to communicate his grievances to the public, in *The State of the Case between Mr Whitaker and Mr Hughes, relative to the Morning Preachership of Berkeley Chapel.* Lond. 1774, 4to. His resentment was so strong, and his discretion so weak, that he thus subjected himself to the vexation of a lawsuit, and the Court of King's Bench held his printed Case to be a libel.

About the year 1778 he resigned his fellowship, on being presented by his college to the rectory of Ruan-Lanyhorne, one of the most valuable livings in the gift of that society. He now withdrew into Cornwall, and took possession of his benefice; and he afterwards married Miss Tregenna, a lady of an ancient Cornish family. For a long time his retirement was not attended with peace and studious ease. His restless and domineering disposition soon involved him in a long train of contentions with his parishioners: he proposed a tithe-composition, which his friends represent as by no means unreasonable, but of which his parishioners appear to have entertained a different opinion; they refused to accede to his proposal, and he demanded the tithes in kind. "Disputes," we are informed, "arose upon disputes; animosities were kindled; and litigations took place. That Mr Whitaker was finally victorious, afforded pleasure to the friends of the rector, *and to the friends of justice and truth;* yet it was long before harmony was restored to Ruan-Lanyhorne." Let us here remark in passing, that this mode of confounding the cause of religion with the cause of tithes is a pretty ancient device. It is not certainly to be considered as wonderful, if, after all these contentions and litigations, Mr Whitaker was subjected to the mortification of observing that his parishioners manifested an aversion to his preaching, an indifference to his admonitions, and a repugnance to his authority. This is indeed the natural consequence of the measures to which he resorted; they have an obvious tendency to excite or continue animosities, and to circumscribe the utility of a clergyman, by rendering him obnoxious to almost every man in his parish who has property enough to bring him within the circle of such litigations. It may perhaps be regarded as extremely doubtful whether any clergyman, possessing a portion of the primitive spirit of Christianity, would be tempted to engage, more especially with his own flock, in quarrels, disputes, and lawsuits, which there

might be any decent means of avoiding. We are informed, that after the lapse of a few years, Mr Whitaker had the satisfaction of perceiving a visible alteration in the behaviour of his principal parishioners, and that a good understanding was at length established between the pastor and his flock. His manner was hearty and familiar; and notwithstanding the rabid spirit that sometimes animates his writings, he was possessed of many virtues, though meekness and humility were certainly not of their number.

His next publication was of a professional kind, namely, *Sermons upon Death, Judgment, Heaven, and Hell.* Lond. 1783, 12mo. He afterwards engaged in the famous controversy respecting the character of Queen Mary, and produced an immense work under the title of *Mary Queen of Scots vindicated.* Lond. 1787, 3 vols. 8vo. He published an enlarged edition in the year 1790; and he seems to have been not a little mortified that neither Lord Hailes nor Dr Robertson could be induced to print a single page against him. This production, which is by no means eminent for coolness of reasoning, or sobriety of manner, has probably convinced very few competent judges of historical evidence, who have submitted to the labour of a patient investigation. If Mary's innocence is so apparent as some of her advocates aver, is it not remarkable that so many bulky volumes should be required to display that innocence? Besides, if we suppose her to be innocent, we must at the same time suppose all the most distinguished of those who opposed her after the murder of her husband, to be covered with an enormous load of infamy. And we will only venture to add, that the uncontroverted history of her proceedings, from a short period preceding the murder, till her indecent nuptials with Bothwell, furnishes a degree of moral evidence which seems to be ineffectually opposed by all the persevering sophistry of her defenders.

Having again recurred to his theological studies, Mr Whitaker published a large volume, entitled *The Origin of Arianism disclosed.* Lond. 1791, 8vo. Whatever might be the opinion of others, it is clear that the author himself entertained a favourable enough opinion of this production; which he represents as "a train of historical argumentation, at once novel in its direction, comprehensive in its scope, and decisive in its efficacy." If he could not discuss a point of history without heat and violence, it is easy to conceive how he would be disposed to discuss a point of heresy. As a proof of his zeal for orthodoxy, an anonymous friend presents us with the following anecdote: "That the feeble Deist should have shrunk from his indignant eye, may well be conceived, when we see his Christian principle and his manly spirit uniting in the rejection of a living of considerable value, which was at this time offered him by an Unitarian patron. He spurned at the temptation, and pitied the seducer." But in order to render this anecdote altogether intelligible, some further information seems to be required. Were his principles so pure and rigid that he could only accept of preferment from a patron of confirmed and approved orthodoxy? Or did this nameless patron offer him the living under the condition, express or implied, that he should become a convert to the Unitarian creed? With respect to the first question, it is quite evident that many pious divines have accepted of preferment from patrons who, to all human appearance, had no religion whatsoever; and with respect to the second, it is equally evident, that no patron, if he possessed common sense, could expect a beneficed clergyman to make an open avowal of opinions which the church has formally condemned as heretical.

Mr Whitaker had contributed to the *English Review* a series of articles on Gibbon's history, which were now reprinted in a separate form, under the title of *Gibbon's History of the Decline and Fall of the Roman Empire,* in Vols. IV. V. and VI. *quarto, reviewed.* Lond. 1791, 8vo. This work, which extends to a considerable volume, is written in his usual vein—with sufficient acuteness and animation, but with little suavity of manner, or elegance of style. He certainly detects errors and exposes inconsistencies; but it may readily be supposed that a writer of his cast of mind was not very likely to form an impartial estimate of Gibbon's real merits, which, after all the fair and necessary deductions are made, must still be allowed to be very great. Mr Whitaker is always an intrepid writer; he is never afraid to deliver a decided opinion; and whether the subject is very familiar or quite new to him, his tone of decision is commonly the same. Thus, for example, in his animadversions on Gibbon's admirable chapter relating to the Roman jurisprudence, he is pleased to declare, that "nothing can subdue the native barrenness of such a field as this." His censure refers to a subject of which he may be considered as in a state of almost total ignorance: he seems to have been alike unacquainted with this science, and incapable of appreciating the masterly manner in which it is here discussed. It may, indeed, be affirmed that there is no portion of Gibbon's work more remarkable than this very chapter: although his early studies had not prepared him for such a task, he has yet exhibited a rapid and powerful sketch of the Roman jurisprudence, to which it might be difficult to find a parallel in the writings of the professed civilians. And it has accordingly been stamped with the approbation of some of the most distinguished civilians of the present age. It has been illustrated by Hugo and Warnkoenig, the former having published it in German, and the latter in French.

After an interval of three years, Mr Whitaker produced a copious work on a subject which is certainly curious and interesting. This work he entitles, in his usual form, *The Course of Hannibal over the Alps ascertained.* Lond. 1794, 2 vols. 8vo. Like some of his former publications, it attracted a considerable degree of attention, and, like them, was thought to contain many hasty and erroneous opinions. On this ground he was encountered by the late Lord Woodhouslee, who published, but without his name, *A Critical Examination of Mr Whitaker's Course of Hannibal over the Alps ascertained.* Lond. 1795, 8vo.

In the year 1795, he endeavoured to enlighten

Whitaker.

the public by an octavo tract on *The real Origin of Government*, which we have never had the pleasure of seeing, but which his friend, formerly quoted, describes as a very singular pamphlet. This information may, without scruple, be received as authentic; for it is not difficult to conjecture how the subject of civil government would be treated by such a writer at such a period.

The last work which Mr Whitaker lived to communicate to the public is *The Ancient Cathedral of Cornwall historically surveyed*. Lond. 1804, 2 vols. 4to. His vigour was still undiminished, and he had formed the plan of many other works, particularly a history of Oxford, and a history of London: the former he intended to comprise in an octavo volume, the latter he contemplated as "quite new and original, and fit to make a quarto." While he was prosecuting his ardent researches into the antiquities of the metropolis, his friends remarked the first indications of declining health. He had originally possessed a robust constitution, but his mind was restless, and his temper ardent; and during his last visit to London, his great exertions in procuring materials for his work, and his great efforts in supporting his usual tone of conversation in the literary circles, left him in a state of debility which was not at first considered as alarming. It was, however, followed by a stroke of palsy, from which his recovery was never so complete as to allow him to resume his occupations with his former vigour. During the last year of his life, he lingered in a state of gradual decay; and he is said to have contemplated his approaching dissolution with the cheerful resignation of a Christian. On Sunday the 30th of October 1808, he sank as into a quiet slumber, without any indication of suffering, and with a smile on his countenance. He died at Ruan-Lanyhorne, at the age of about seventy-three, and left a widow and two daughters.

He had recently sent to the press an antiquarian volume, which was soon afterwards published under the title of *The Life of Saint Neot, the oldest of all the Brothers of King Alfred*. Lond. 1809, 8vo. The preface is written by his publisher, Mr Stockdale. All his principal works have now been enumerated, but a few supplementary notices are still necessary. He wrote an introduction to Flindell's *Bible*, and a supplement to Polwhele's *Antiquities of Cornwall*, and was a contributor to *The Cornwall and Devon Poets*. His connection with the *English Review* has already been mentioned; but he likewise appears to have lent his aid to the *British Critic* and the *Antijacobin Review;* and his eulogist informs us, in a very solemn style, that "the strength of his principles is no where more apparent than in those articles where he comes forward, armed with the panoply of truth, in defence of our civil and ecclesiastical constitution. It was there he struck his adversaries with consternation, and we beheld the host of Jacobins shrinking away from before his face, and creeping into their caverns of darkness." The same tasteful and judicious writer avers, that at Whitaker's lucubrations "a Gibbon trembled;" but this panegyric is somewhat abated by another piece of information, namely, that Gibbon was a "feeble Deist."

Whitaker || Wicklow.

With what torrents of fiery indignation this worthy divine must, in his fugitive and anonymous writings, have overwhelmed Jacobins and heretics, may very easily be imagined by those who have inspected his more élaborate works, bearing his name and addition, and intended for the benefit of posterity. Some persons of cooler tempers, and of more habitual candour, when they are fairly enveloped in the cover of a review, may now and then be tempted to speak in a very high and arrogant tone to men greatly elevated above their own standard, and of subjects of which they only possess a very casual and superficial knowledge.

This anonymous writer, whom we strongly suspect to be Mr Polwhele, has, in the following passage, discussed the character of Mr Whitaker with more sobriety and discrimination. "It is true, to the same warmth of temper, together with a sense of good intentions, we must attribute an irritability at times destructive of social comfort, an impetuousness that brooked not opposition, and bore down all before it. This precipitation was in part also to be traced to his ignorance of the world; to his simplicity in believing others like himself—precisely what they seemed to be; and, on the detection of his error, his anger at dissimulation or hypocrisy. But his general good humour, his hospitality, and his convivial pleasantry, were surely enough to atone for those sudden bursts of passion, those flashes which betrayed his 'human frailty,' but still argued genius. And they who knew how 'fearfully and wonderfully he was made,' could bear from a Whitaker what they could not so well have tolerated in another. In his family, Mr Whitaker was uniformly regular; nor did he suffer at any time his literary cares to trench on his domestic duties. The loss of such a man must be deemed, as it were, a chasm both in public and private life. But, for the latter, we may truly say, that if ever wife had cause to lament the kind and faithful husband, or children the affectionate parent, or servants the indulgent master, the family at Ruan-Lanyhorne must feel their loss irreparable." (*Gentleman's Magazine*, vol. lxxviii. p. 1037. See likewise Nichols's *Literary Anecdotes of the Eighteenth Century*, vol. iii. p. 105.) (w. w. w.)

Boundaries.

WICKLOW is a county in the province of Leinster in Ireland, bounded by Dublin and Kildare on the north; by Wexford on the south; by St George's Channel on the east; and by Kildare, Dublin, and Carlow on the west. It extends about 40 English miles from north to south, and 33 from east to west, containing 781 square miles, or nearly 500,000 English acres, and is divided into six baronies and half baronies, and 58 parishes. Of these parishes, 49 are situated in the archbishopric of Dublin, six in the diocese of Leighlin, and three in that of Ferns.

Extent.

Divisions.

Surface.

The outline of this county is rendered very irregular by a district on the south-west, the barony of Shillelagh, being almost detached from the rest of it, projecting between the counties of Carlow and Wexford. On the east, the sea-coast stretches almost in an unbroken line, except a little to the south of the town of Wicklow, where there is a promontory called Wicklow Head. Bray Head, another point, is on the northern extremity. Mountains and bogs oc-

Wicklow. cupy a great part of the interior, from the north along the centre of the district, to the barony of Shillelagh. Much of this tract is without inhabitants. To the north and west these mountains are bold and abrupt; but on the east they are penetrated by several beautiful glens, of which the Dargle, the glen of the Downs, the vale of Imalee, and Glendallogh, are the most celebrated. Some of these are of considerable extent, finely wooded and watered, and, with the mountains which inclose them, exhibit a great variety of romantic scenery. In these glens much of the wood is oak, but not of a large size. Detached hills also abound on either side of this range, though on the east, south, and west, the country is in general low and fertile. It has been compared, not inaptly, to a frieze cloak with a laced border. In the central range, the prevailing rock is granite, and argillaceous schist in the less elevated hills on the east and south. On the north, near the confines of Dublin county, is a remarkable chasm, called the Scalp, in a ridge of granite. Calcareous strata occur on the west, and also on the east, from Wicklow to Bray; but no limestone has been found in continuous rocks. In these quarters, it is in the form of pebbles or gravel.

Minerals. Wicklow is thought to be rich in metallic substances, particularly on the south, from the Croughan Mountain to the hill of Cronebane, about ten miles to the north-east. In this tract copper has been wrought at Cronebane and Ballymurtagh to a considerable extent. In 1809, the Cronebane mines produced about 3000 tons of ore annually, at an expence of L. 8000; but at both places the works were

Gold Mines. soon after discontinued. Native gold has been found on the north-east side of the mountains Croughan Kinshela, on the summit of which this county meets with that of Wexford, in a stream which falls into the Ovoca, and also on the south side of these mountains. In 1796, gold was obtained to the value of L.10,000, sometimes in pieces of considerable weight; one of them weighed nine, a second eighteen, and a third even twenty-two ounces. The search was then undertaken by Government, both in the mountains themselves and the streams which flow from them; but no veins were discovered, and the works have been long since abandoned. Lead has been worked at Glenmaher and in Glendallogh, or the Seven Churches. At the latter place, in 1809, there were three smelting houses, and about 180 bars, weighing one hundred weight each, were made *per* week.

Rivers. The rivers are the Liffey, which has its rise on the north-west quarter of this county, and passes into that of Dublin; the Ovoca, which flows into the sea at Arklow; and the Slaney, which, rising in the south-west, proceeds southward into the county of Carlow. None of these rivers are navigable in their course through this district. There are no extensive lakes; the most considerable are Lough Bray, Lough Tay, Lough Dan, and the loughs of the Seven Churches. Some of the streams precipitate themselves from considerable heights, forming beautiful cascades; the most remarkable one is at Powerscourt, where the water falls from a height of 360 feet.

Climate. The climate of this county is remarkably mild. Myrtle flourishes in such profusion as to have been sometimes used for making stable-brooms. The common laurel, Portugal laurel, and arbutus, attain a great size, and can scarcely be recognized to be the same shrubs. Dublin is supplied with early potatoes and house-lamb from the sea-coast of Wicklow, the climate of which, according to Mr Wakefield, is decidedly different from that of the rest of Ireland. This is the only part of that country where he ever saw grapes growing out of doors.

Estates and Farms. There are several large estates in Wicklow. That of Earl Fitzwilliam extends to 66,000 Irish acres. The centre of the county, which consists of bogs and mountains, and is uninhabited, belongs chiefly to the see of Dublin. The district of the sea-coast, however, is much divided, and abounds with villas, the temporary residence of the wealthy citizens of Dublin. "It appears to me," says Mr Wakefield, "to contain more gentlemen's seats than the same space in the vicinity of London." The common period of leases is twenty-one years and a life. On the sea-coast, land lets at from L. 3 to L. 5 *per* Irish acre, or about 47s. the English acre, and on the north-east, near Dublin, it is considerably higher. Potatoes, and all the usual kinds of corn, are cultivated; but turnips, clover, and other ameliorating crops, only partially. Marl and limestone gravel are the principal manures. Irrigation is practised according to the method common in England. A breed of fine-woolled sheep, peculiar to the mountains of this county, exhibit the only traces of a distinct race of short-woolled sheep in Ireland.

Manufactures. Besides the manufacture of coarse woollens for domestic use, flannel is made to a considerable amount for sale; there is a Flannel Hall at Rathdrum, at which, before 1808, from 5000 to 7000 pieces were sold annually. The cotton trade was, at that period, in a flourishing condition at Stratford on the western side of the county. But the linen manufacture, so general in other parts of Ireland, is carried on here only to a small extent. There are no good harbours, nor any canal or navigable river, in this district. Wicklow harbour has only from seven to eight feet of water on its bar at high tides. Wicklow, the county town, with Baltinglass, Blessington, and Carysfort, were Parliamentary boroughs before the Union, though, excepting the first, none of them contained, at that time, 1000 inhabitants, and Wicklow itself not many more. The villages are Bray, Rathdrum, Arklow, Stratford-upon-Slaney, and a few others. Of these Arklow, the most considerable, contained about 2600 inhabitants. A battle was fought there 9th June 1798, in which the rebels, computed to be about 31,000, were defeated, by General Needham, with a mixed force, said not to have exceeded 1500. The herring-fishery, in the

Herring-Fishery. bay of Arklow, which, next to that of Galway, is considered the best in Ireland, employed, in 1816, from 100 to 150 boats, and has sometimes produced about L.25,000 yearly.

Population. The population of this county, in 1790, was about 58,000. According to the census taken in 1821, it was 115,162. Mr Wakefield computes the proportion of the Catholics to the Protestants to be as ten to one. In the parish of Arklow, according

Wicklow || Wigtownshire.

to the writer of that Article in the *Parochial Survey*, the proportion is only as three to one. The county sends two members to Parliament, both of whom may be returned by the influence of Earl Fitzwilliam. The wages of labour and the prices of provisions being affected by the vicinity of Dublin, are higher than in most parts of Ireland, and the condition of the lower classes is said to be more comfortable.

Representation.

See Frazer's *General View of the Agriculture, &c. of the County of Wicklow*, and the works of Beaufort and Wakefield, as quoted under the former Irish counties. (A.)

Situation and Boundaries.

WIGTOWNSHIRE, a maritime county on the south-west extremity of Scotland, situated between 54° 38′ and 55° 4′ north latitude, and between 4° 16′ and 5° 6′ west longitude. This, with the stewartry of Kirkcudbright, now forms the province of Galloway, which was once more extensive. It is bounded by the stewartry of Kirkcudbright on the east; by the Irish Sea on the south and west, and by Ayrshire on the north, containing 485 square miles, or about 310,000 English acres, and is divided into seventeen parishes. About a third of the land is productive or cultivated, and the rest is in its natural state, and comparatively of little value.

Extent.

The district is of a very irregular form, the western side being almost cut off from the rest by two arms of the sea, Luce Bay on the south, and Lochryan on the north; while Wigtown Bay, which separates it from Kirkcudbright, penetrates it on the east. It is popularly divided into the *Rhinns*, the *Machers*, and the *Moors*. The *Rhinns*, which signifies points or promontories, consists principally of the peninsula lying west of Lochryan and the bay of Luce, being the nearest land in Britain to Ireland, and terminating on the south in the Mull of Galloway, the most southerly land in Scotland; from whence may be seen, in a fine day, the Isle of Man and the shores of England and Ireland. It is connected with the rest of Wigtownshire by an isthmus about six miles broad, which seems to have been at one time overflowed by the sea. The *Machers* is a large promontory, none of it much elevated, which runs out to the south-east between the bays of Wigtown and Luce; and the *Moors* are spread over the rest of the county, but chiefly on its northern side, where it is bounded by Ayrshire.

Divisions.

Surface.

The surface of this county, except in the northern quarter, where the hills rise to 1000 feet and upwards, is very little elevated above the sea; but, exclusive of a narrow tract of alluvial land near the bottom of the bay of Wigtown, there is very little that is flat or level. It consists, for the most part, of a great many low hills and gently undulating grounds, often broken by detached rocks which rise a few feet above the surface, and interspersed with considerable tracts of mossy and moorish soils, even in the lower and more cultivated parts; being similar in this respect to the stewartry of Kirkcudbright, the other division of Galloway. (See KIRKCUDBRIGHT in this *Supplement.*)

Climate.

The climate, though moist, is mild and salubrious, especially in the low grounds, the prevailing winds being from the south-west. In the *Rhinns* rains are more frequent than in the *Machers* on the south-east; but the winters on this coast are every where milder than on the eastern coast of Scotland; and no part of the county is more than ten or twelve miles from the sea. In summer, however, there is also less sunshine, and, for this reason, the crops of wheat and barley, particularly the former, are commonly inferior in quality to those raised on the eastern side of the island.

Soil.

The soil of the arable land is, for the most part, of a hazel colour and shallow, but dry and not unfertile, and well adapted to turnip husbandry. On the bay of Wigtown, there is a tract of rich alluvial land, fit for the growth of wheat and beans, similar to the Carse lands of Gowrie, and other tracts on the Forth and Tay; but this and every other description of clay land forms but a very small proportion of the whole. On the western side, between the bay of Luce and Lochryan, the soil is chiefly a deposition of sea sand, interspersed with considerable tracts of flow moss. In this quarter, near Glenluce, there is an extensive rabbit-warren, said to yield about L.400 a-year. Much of the higher grounds, or the *Moors*, is wet, spongy, and sterile, producing herbage very inferior to that of the hills on the south-east of Scotland, and depastured by a small kind of coarse-woolled heath-sheep, and an inferior variety of the native cattle.

Rivers.

The rivers are, the Cree, the Bladenoch, and the Luce, with a number of smaller streams. The Cree, which rises among the mountains of Carrick in Ayrshire, enters this county from the north, and, flowing along the boundary with Kirkcudbright, falls into the bay of Wigtown a little above the town of that name; and it is navigable upwards to the Carty a little below Newton-Stewart. The Bladenoch, after a circuitous course of about twenty-four miles, also enters the bay of Wigtown, and, by means of the tide, admits small vessels a little above its mouth. The Luce, the only other stream of any size, after a northern course, falls into Luce Bay at the town of Glenluce. These streams are frequented by salmon, of which there are one or two considerable fisheries on the bay of Wigtown. There are several lakes, but none of them worthy of particular notice. Lochryan, though it has all the appearance of a lake, is an arm of the sea, and is of great importance as affording a safe and commodious harbour, with an inland navigation for eight or ten miles, and occasionally a productive herring-fishery.

Valuation and Rental.

The valued rent of Wigtownshire, as taken in 1642, is L. 67,641, 17s. Scots, and the real rent of the lands and houses, in 1812, was L. 131,778, 12s. 10d. Sterling; the land rent being about 8s. an English acre. This is divided among a few great proprietors, one of whom has a rental of upwards of L.30,000, and several others have from L. 5000 to L. 10,000 and upwards. More than half the county is held under entail. The territory is further divided into farms of a moderate size, on the arable lands seldom exceeding 200 or 300 acres, which are held on leases for 19 or 21 years, as in other parts of Scotland. It was formerly the practice to add the life of the tenant; and some of these leases still subsist, but few are now granted but for a term of years certain. In no part of Scotland, perhaps, have rents risen more than in this quarter. "A variety of instances," says the

Farms.

Rents and Agriculture.

Wigtownshire.

author of the *Agricultural Survey*, "might be adduced where the present rents of farms are equal to the prices paid for them in the memory of persons still living." Yet an improved system of agriculture has not kept pace with this advance of rent, which has been chiefly occasioned by the increased demand of the English markets for their cattle, which are much esteemed in every part of the island. (See AGRICULTURE in this *Supplement*.) The management of the arable land, though improved within these few years, is still very much inferior to that which prevails in the eastern and other lowland counties of Scotland. The principal corn crops are oats and barley, or rather bear; the potatoe, which occupies a considerable portion of every farm, is still a much greater favourite than the turnip; and where turnips are raised they are, with few exceptions, carried off the ground, instead of being consumed on it by sheep, according to the practice of the eastern counties. It is, therefore, to their cattle principally that the farmers trust for payment of their rents, and a great portion of even the best arable land is still appropriated to grazing. On the western side, the dairy has been introduced within these few years by farmers from Ayrshire, and found to answer better, it is said, than the system common in other parts of the county. One of the largest dairies in Scotland is in this quarter. Almost all the land, even the higher grounds, is enclosed chiefly with stone fences, well known by the name of *Galloway dykes*; and of late, a considerable improvement has taken place in the farm-houses and offices, many of which have been constructed in a substantial manner. There is very little natural wood; but considerable plantations have been formed by some of the principal proprietors. Among the trees found most able to endure the sea spray, and resist the westerly winds, are the pinaster and the Huntington willow, which thrive almost on the sea beach. On many parts of the coast large banks of shells have been formed, which are used as manure, in place of lime, and in others sea-weeds are used for the same purpose; lime as well as coal must be imported from Cumberland and the west of Scotland, there being none of either in the county. From the want of coal, the principal article of fuel used in the interior is peat and turf.

Dairies.

Towns.

Wigtownshire has three royal burghs; Wigtown, the county town, situated at the bottom of the bay of that name; Whithorn, near the south-eastern point of the Machers division; and Stranraer, at the bottom of Lochryan. In the elections for the Scottish burghs, these, with New Galloway in the stewartry of Kirkcudbright, send one member to Parliament; the county, in which there are about sixty freeholders, being also represented by one. None of these towns, however, are extensive or populous. The villages are Newton Stewart on the Cree, Garlieston, a small sea port on the bay of Wigtown, New Luce, an inland village a few miles east from Stranraer, Glenluce, at the bottom of Luce Bay, and Portpatrick, on the west side of the Rhinns division, on the great thoroughfare between Britain and Ireland; the Channel, between Portpatrick and Donaghadee on the Irish coast, being only about twenty miles broad. There are no manufactures of any consequence, and no other trade but what is carried on in small vessels with the nearest ports of England and Ireland and the west of Scotland, for the export of their raw produce, and the import of coal, lime, and other articles required for consumption. In the weights and measures used here, there is now less variety than in most other parts of Scotland, the Winchester bushel and the avoirdupois weight being in general use. By the former, all the corn, potatoes, &c. are measured, and the prices stated; the weight of the corn, however, being attended to, in estimating its value, as well as the measure. Thus, a bushel of wheat weighing 60 lbs. is worth more than the same measure, of which the weight is only 56 lbs. It is to be wished that this practice were general in other parts of Scotland, where the great diversity of weights and measures, sometimes even in the same county, occasions so much inconvenience.

Representation.

Wigtownshire || Wiltshire.

Trade. Weights and Measures.

Antiquities.

Wigtownshire is not rich in antiquities. The most noted ruins are those of Dunskey Castle, situated on the verge of a precipice, a little to the south of Portpatrick; Castle Kennedy, the ancient seat of the family of Cassillis, in the parish of Insch; and the abbey of Glenluce. But the most interesting remains of this kind, perhaps, are what are called the Standing Stones of Torrhouse, in the parish of Wigtown; consisting of 19 erect pieces of granite, within a circle of 218 feet, and several large stones standing singly at a little distance to the south and east. There are also two cairns or barrows in the same quarter.

Population.

The population, according to the census of 1801, was 22,918; in 1811 it had increased to 26,891; and in 1821 to 33,240; of which 15,837 were males, and 17,403 were females. The *families* employed in agriculture were 3525; in trade and manufactures 2089, in all other occupations 1160. The increase of population from 1811 to 1821 was 6349.

See Smith's *Survey of Galloway*, and the general works quoted under the former Scottish counties.

(A.)

Boundaries, Extent, and Divisions.

WILTSHIRE, an inland county of England, in the western judicial circuit. It is bounded on the north-west and west by the county of Gloucestershire; on the west by Somersetshire; on the south by Dorset and Hants; and on the east and north-east by the latter county and Berkshire. The length is about 50 miles, and the breadth about 34. It is of an elliptical form, with very irregular indentations on the borders. The area is 1379 square miles, or 882,560 statute acres. The county is divided into twenty-nine hundreds, comprising one city, 23 market towns, and 295 parishes. The whole of the county, with the exception of the parish of Kingswood, is in the diocese of Salisbury, and is ecclesiastically divided into two archdeaconries, which are subdivided into ten deaneries.

Population.

By the census of 1821, Wiltshire appeared to contain 43,125 houses, inhabited by 47,684 *families*; of whom 24,972 were employed chiefly in agriculture; 16,982 in trade, manufactures, or handicraft; and 5730 were not comprised in either of these classes. The whole number of *persons* was 222,157, of whom 108,213 were males, and 113,944 females. The increase of population between the census of

Wiltshire.

1811 and that of 1821 was at the rate of 15 *per cent*.

Face of the Country and Cultivation.

The southern division of Wiltshire is chiefly that extensive tract of unwooded land usually denominated Salisbury Plain. It is an uninclosed country, and from thence has an appearance of desolateness; but bottoms are frequent, and having generally streams of water running through them, the houses and villages are, for the most part, erected in them, and the district is much more populous than a traveller passing over the plain would suspect. The land, though chiefly used for feeding sheep, is, when brought under the plough, highly productive in turnips, barley, and wheat. There is a tract of rich land between Salisbury Plain and Marlborough Downs; and to the north of these downs the country is well inclosed, and abounds in rich pasture, on which are fed the cows that produce the excellent cheese known by the name of North Wiltshire. The peculiar breed of sheep of this county, and which are universally called by its name, are all horned, afford heavy fleeces of moderately fine wool, and are very numerous; on Salisbury Plain they are said to be more than 500,000. The produce of wheat and other grain is estimated to be less *per* acre than the general average of the contiguous counties. There were anciently several extensive forests in this county, and, though the districts still retain the name either of *Forest* or *Chace*, they are, with the exception of Savernake or Marlborough Forest, and Cranbourn Chace, almost wholly now either in pasture or under the plough.

Rivers and Canals.

Wiltshire being an elevated district, many rivers have their sources in it, or water the lands of it soon after their rise. The most important of these are the Thames, the Lower Avon, and the Kennet, all of which are navigable. Besides these are the tributary streams, the Upper Avon, the Willey, the Nadder, the Bourne, the Stour, and the Brue. The canals which pass from or through this county are the Thames and Severn, connecting those two rivers with each other; the Kennet and Avon, which also unites those rivers. Both of these canals have been most expensive, and, hitherto, unproductive undertakings, designed to facilitate the intercourse between London and Bristol. The Wilts and Berks Canal, designed to connect the Severn with the Thames, has been especially an unfortunate concern. The Salisbury and Southampton Canal has been found of some benefit, by supplying the former place with coals, but has been little productive to the proprietors.

Manufactures.

This county has long been one of the chief districts for the manufacture of fine cloths. That branch of industry is now, however, confined to the western part of it. The populous towns of Bradford, Trowbridge, Devizes, Warminster, Chippenham, Westbury, Melksham, Calne, and the villages surrounding them, are chiefly maintained by making cloths and casimeres of fine quality, the wool for which used to be imported from Spain to Bristol, but of late years the fine wools of Saxony have in a great measure supplanted those of Spain in this country. Salisbury is distinguished by its manufactory of fine flannels, and by cutlery and steel articles of superior quality. Wilton makes carpets and fine cloths. At Mere and in its vicinity linen goods, chiefly dowlass and bed ticks, are made. At Swindon are many manufacturers of gloves.

Antiquities.

Few counties present so many objects of antiquarian research as Wiltshire. Among those of British origin are the Wansdike, a fortification of earth traversing the whole county; the druidical masses of stone at Stonehenge and Avebury; the numerous *barrows*, or *tumuli*, which are to be seen on a great number of spots on the Downs; and the earthen ramparts supposed to have formerly inclosed the towns of the ancient Britons. Among the Roman antiquities are many of the roads constructed by that people, their fortified encampments, and the ruins of several of their castles, especially those of Marlborough, Devizes, Malmesbury, and Old Sarum. The monastic remains, especially at Malmesbury, present very interesting subjects of study to the antiquarian. Besides these vestiges of antiquity, tesselated pavements, coins, urns, fragments of sculpture, daggers, shields and ornaments of British, Roman, Saxon, and Norman fashion, have been discovered. The cathedral of Salisbury, though not of such an age as to be classed among antiquities, is an object of great admiration on account of the elegant design and scientific execution of the structure. The beautiful spire is much admired for its height and its proportions, and though in a valley, may be seen at a great distance rising above the surrounding hills. It is said to be the loftiest in England, rising from the floor of the church to the height of 400 feet.

Titles and Representation.

The following Peers derive their titles from this county: Duke of Marlborough, Marquises of Lansdowne and Salisbury, Earl of Malmesbury, Viscount Bolingbroke, Baron Arundel. Two members are returned to the House of Commons by the county, and two each from Salisbury, Chippenham, Calne, Cricklade, Downton, Devizes, Heytesbury, Hindon, Great Bedwin, Marlborough, Malmesbury, Ludgershall, Westbury, Wilton, Wotton Basset, and Old Sarum.

Towns.

The chief places and their population are as follow: Salisbury, 8763; Trowbridge, 9545; Warminster, 5612; Melksham, 4765; Calne, 4549; Devizes, 4208; Bradford, 3760; Chippenham, 3201; Downton, 3114; and Marlborough, 3038.

Chief Seats.

Among a great number of seats belonging to noblemen and gentlemen, the most remarkable are Longleat, the Marquis of Bath; Bowood, Marquis of Lansdowne; Tottenham Park, Lord Aylesbury; Wardour Castle, Lord Arundel; Fonthill Abbey, late Mr Beckford; Wilton, Earl of Pembroke; Stourhead, Sir R. C. Hoare; Longford Castle, Earl of Radnor; New Park, Thomas Estcourt, Esq.; Dinton House, William Wyndham, Esq.; Corsham House, P. C. Methuen; Wilbury House, Sir C. W. Malet; Charlton Park, Earl of Suffolk; Stoke Park, Joshua Smith, Esq.; Bradley, Duke of Somerset; and Ramsbury, Sir Francis Burdett.

See Davis's *View of the Agriculture of the County of Wilts.—The Ancient History of South Wiltshire*, by Sir Richard Colt Hoare, Bart.—Aubrey's *Introduction to the Survey and Natural History of North Wiltshire.—The Beauties of Wiltshire displayed in Statistical, Historical, and Descriptive Sketches*, by John Britton.

(W. W.)

WINE-MAKING.

Wine-Making.

THE history of wines is both curious and amusing; and their topography is not less so, if we may apply this term to the several kinds, to their enumeration, and to that of the countries where they grow, and to the variations followed in their manufacture. This is a subject which would occupy a volume; and we must therefore pass it over, that we may dwell on what is of more moment, the general mode of making this important article, and the several chemical circumstances connected with it. France is the only nation which has bestowed much attention on the philosophy of this subject, as it is that which excels all others in the variety and the goodness of its produce.

Fruits, their Nature.

Vinous liquors, resembling wine, may be made from every fruit, as well as from every vegetable which contains acids united to its extractive matter. The term wine is thus applied to the produce of currants, gooseberries, and many others; while that of cyder is especially reserved for the liquor to be obtained from apples. That term would be a fitter one for many of the vinous liquors in question, and we shall here restrict the term *wine* to the produce of the vine.

All fruits consist of the following principles: water, sugar, a peculiar combination of sugar and extract, called the sweet principle by the French, supertartrite of potash, malat of potash, and malic acid, superoxalate of potash, extractive matter analogous to mucilage, and vegetable gelatin, tannin, a principle of flavour, and a colouring principle. These, however, are not all found in any one fruit, and they also vary in their proportion in different ones. The essential ones to the making of wine are the tartarous acid, sugar, or the sweet principle, extract, and water; and those which are useful, without being indispensable, are flavour, tannin, or astringency, and colour. And it is by possessing these in right proportions that the grape excels all other fruits for the purpose of making wine.

Effects of the Principles of Fruits.

Tartarous acid, or its combinations, is especially indispensable: and hence it is that the grape, which contains it in large quantity, produces wine; when the apple, and other fruits which contain the malic acid, produce cyder. It is essential to the fermentation, as well as to the quality of the produce; and it is decomposed in the process so as to increase the quantity of alcohol, which the sugar would otherwise yield. Where malic acid is also present, the quality of the wine is bad. Sugar must be considered the fundamental element, and as that from which the alcohol is chiefly derived. Thus the most saccharine grapes produce the strongest wine. But it seldom exists in a pure state in the grape, or in any other vegetable. It appears to be most pure in the sugar cane; but even there it is combined with the extractive matter, and also with some acid, forming the sweet principle of the French. Pure sugar does not ferment in water, it crystallizes; and whenever fermentation occurs, some other vegetable matter is present. When sugar, again, has crystallized from a solution of the sweet principle, what remains runs still more readily into fermentation. In the produce of the cane, this is molasses. It is very important to keep this distinction in view, because the fabrication of sweet wines depends materially upon it. It explains many circumstances in the process of fermentation, and some that are often overlooked. It explains, among other things, why wine ferments in a cask when it will not ferment in bottles; because the sugar derives the necessary extractive matter from the wood. The chemical nature of the extractive matter is not known; but it is supposed to contain azote, as this is the produce of fermentation. Yeast, or leaven, contains the extractive principle in great abundance, and hence its power in inducing fermentation in a solution of pure sugar. All vegetables contain it; and it is most abundant in those juices which gelatinate in boiling. It is found in the grape, and it is thus the natural leaven of wine, whether existing in a separate state or united to sugar in the form of the sweet principle. Water is a much more essential ingredient than would at first be suspected. If over abundant, it is difficult to prevent the produce from running to the acetous stage. Hence weak wines become sour. If deficient, it is difficult to establish the fermentation; and hence sweet wines. Thus, also, sweet wines are insured by drying the grapes, or evaporating their juice, both common practices in the wine countries. Colour must be looked on in the light of an ornament, and is found in the husk of the grape. So is the tannin principle, which occasions astringency in Port wine. Of the principle of flavour chemistry knows nothing; it seems often the produce of fermentation, as in Claret and Burgundy wines: in those of Frontignan and Muscat it is the natural flavour of the fruit.

On Fermentation.

When the process is complete, the wine is dry, or contains no sugar, so that sweet wines, which are compounds of wine and sugar, are the produce of an incomplete fermentation. When all the elements above described are in due proportion, the product is perfect, a dry wine; and the elements that require particularly to be balanced for this result are the extract, or leaven, and the sugar. If the former is in excess, the wine tends to vinegar, unless means are used to stop the fermentation by abstracting the leaven; if in defect, the process is imperfect, a sweet wine. Hence the perfection and management of the leaven are among the most important circumstances in the manufacture. It is coagulable partially by heat; and hence also it is, as well as by evaporating the water, that boiled *must* produces sweet wine. It is also abstracted by precipitation, and by the action of sulphurous acids; whence other processes in use in wine-making.

In fermentation, the superfluous extract or leaven is separated in two forms, that of yeast and lees;

Wine-Making.

and these will excite that process in fresh solutions of sugar, or renew it, or continue it, in the mixture whence it was separated; whence racking and fining. There is, however, one important difference between the natural or original, and this artificial or secondary leaven. The latter is soluble in hot water, and not in cold; and hence it is separated in fermentation. By restoring this separated matter to wine in the course of fabrication, the fermenting process is prolonged, or the wine rendered drier; by skimming, and fining, and racking, the process is checked: and hence the application of these practices to sweet wines. The *rolling* of wine, or returning on its lees to *feed*, is hence understood; and hence also the improvement which certain wines experience in long voyages. But the same principle and process which improves Madeira destroys Burgundy, and the reason must now be obvious. The theory of racking, fining, and sulphuring, is hence also apparent; and, of the sulphurous acid, it is a property to combine with the leaven, and form an insoluble separable compound. It is thus that it checks fermentation. Hence, also, it is that sweet wines do not turn sour: their leaven has been expended. Thus also we may see that the process of fermentation is not an unmanageable and a precarious one; but that the essential ingredients are in our power, and that we can modify them to the desired result. If it has been stopped prematurely, it may be renewed by fresh leaven; if in excess, it may be checked or suspended. And thus it is too, that dry wines, and fined wines, and wines in bottles, are durable, when they would perish in the cask.

The acid was shown to be also essential to the produce of wine. Mere extract, or leaven, and sugar, produce beer, not wine. Tartarous acid cannot well be in excess in that compound in which it exists, viz. the supertartrite of potash; because it is a salt of difficult solution, and the superfluity is precipitated; hence the tartar of wine-casks; hence, also, the crystals which are seen, in cold weather, to float in Madeira wine. We noticed that it was decomposed in the fermentation, and was thought to contribute to the quantity of alcohol. The French chemists also assert that a part of it is converted into the malic; hence the peculiar properties of some wines; hence also the practice of liming the vats, or of sprinkling the grapes with lime in the manufacture of Sherry wines; whence they acquire that peculiar dry and hard taste which distinguishes them from the wines of Madeira. As the tartarous salt adds to the fermenting power of the fluid, hence we explain the facility with which the juice of green grapes runs into fermentation when compared with ripe ones; the immature fruit containing a much larger proportion of this salt than the mature. Thus also those wines continue to ferment longer, or to retain the power of fermenting; and hence the vivacity of Champagne wines, the most effervescent kinds of which are made from half ripened fruit.

Circumstances of Fermentation.

The temperature of 54° Fahrenheit is considered the most favourable to this process. In extreme heat it fails, as in extreme cold. Hence the difficulty of making wine in India, and the West Indian islands. Hence also, in the temperate climates, we have it in our power to regulate fermentation by the use of heat or of cold. Hence, also, it is that wines which had ceased to ferment, recommence in spring; and hence, one of the processes essential to the manufactures of Champagne wines; namely, that of watching the spring fermentation, and bottling the wines in this stage.

Air is necessary to fermentation, rather than essential. The operation does not cease in closed vessels, but is retarded. Air is not absorbed in the vinous fermentation; although its oxygen is in the acetous. The wine is stronger in close vessels, if the process is slower, because a portion of the alcohol escapes from the vats: and this is now understood in our malt distilleries. That alcohol is held in solution in the carbonic acid which is generated; and thus, it appears, to intoxicate more rapidly; as is well known in Champagne wines. Under pressure, this compound is united to the fluid; and, being disengaged, produces the well known effervescence. The practice of fermentation is partly regulated by this consideration. The violent stage of that process in wine-making is allowed to take place in an open vat: the next is partially checked by an occasional bung, and, in the last of all, the vessel is completely closed. In strong still wines, the whole process may be conducted in open vessels: but, in light and brisk ones, it is absolutely necessary that the last part should take place in closed ones. Champagne wines are managed so as to ferment even in their bottles.

The volume of the fermenting fluid has a considerable effect on the process; a few days are sufficient to complete it when the quantity is large. When small, it is difficult to establish, and tedious in the progress, and the results are also different: wines of different qualities being thus produced from the very same materials. It is the same in the ultimate fermentation or ripening of wines. Champagne would be destroyed in a large cask: porter, an extreme case, is ripened in enormous masses, as are many of the stronger wines. Bulk is peculiarly required for the strong and sweet wines; Champagne may be made in a gallon measure.

Phenomena of Fermentation.

The first appearance is the production of air bubbles, terminating at length in a general ebullition. The liquor then becomes turbid, a variety of solid matters are disengaged, some falling to the bottom, and others rising to the top of the fluid. The leaven, before mentioned, is thus separated among other matters, while the bulk of the fluid is materially increased. It is in this stage that we have the power of regulating the extent of the fermentation; by separating the floating leaven, or allowing it to return into the liquor. Hence, the process of fermenting in a full cask, ejecting that substance by the bung-hole.

The disengaged gas is carbonic acid chiefly: but holding, as first remarked, some alcohol in solution. It appears, by analysis, that this is the produce of part of the carbon of the sugar and of its oxygen; and this is the great change which leads to the production of the alcohol. But it also contains some obscure vegetable matter in suspension; because, if passed through water, it not only converts it into vinegar, but deposits that mucilage, which, in vinegar, is called the *mother*. It is possible, however, that this may itself be a new compound: and it is

one which, in certain cases, contains azote. That substance, which exists in yeast, has also been found in the disengaged gas, partly, it is said, in the form of ammonia: and hence, possibly a nauseous ammoniacal taste, well known in bad wines, and very remarkable in those of the Cape of Good Hope.

The generation of heat is one of the most remarkable phenomena in fermentation, and it bears a proportion to the bulk of the fluid. It is sometimes so great as to render it necessary to reduce it by art; its cause is obscure. The colour of wines is also produced during the fermentation; the red appears to be a substance analogous to resin, soluble in alcohol; and thus its production is accounted for. Hence, white wines may be made from red grapes, by excluding the husks; hence also, red wines are often astringent; because the tannin also lies in the husk. Thus also, in Champagne wines, the red are generally inferior; because, the species of fermentation required to extract the colour dissipates part of the flavour.

The formation of alcohol is the last, and the essential phenomenon; and it is now plain, how this must depend on the quantity of sugar, on the goodness of the fruit, on the due apportioning of the leaven, and on the management of the process.

Thus, when all the necessary circumstances are present, the process goes on till the produce is pure wine, or a compound of alcohol, water, acid, colour, vegetable extract, and sugar. For although the two latter are said to be destroyed, there is almost always a minute portion of both remaining; the former rendered very sensible, in some wines, by the skinny matter which they deposit on the sides of the bottles. In a similar manner, it happens, that a portion of sugar continues attached to the wine for a long time, though it is not always sensible except to a fine taste. Thus, it is perceptible in Claret, and even in Madeira, which are among the driest of our wines. It is often very sensible in Port; and, when in excess, is commonly the mark of a bad wine. In the first stages of the fermentation, the sugar is never thoroughly decomposed. If that were the case, indeed, the process would stop, or it would proceed to vinegar. Farther fermentation, that slower species which takes place in the casks, tends farther to diminish it; but, still a portion remains, even when it has been bottled.

It is the gradual conversion of this sugar, the chief operation that goes on in bottled wines, which is the cause of the change which these undergo. This process often requires many years for its completion: that is the case in the Clarets of Chateau Margaux, and other Bourdeaux wines; and the same process indeed takes place, to a greater or less degree, in Madeira and the other strong wines. In these cases, it is a cause of improvement; the wine becoming more perfect under this last tedious fermentation; in others, however, it is mischievous: and hence the destruction of many wines. Thus, Champagne is destroyed, and often very quickly: thus, Burgundy also is easily ruined; and thus, even our Port is not a very durable wine, though the destruction is here accelerated by the intermixture of brandy used in this particular manufacture. Age, which thus meliorates one wine, destroys another, independently of that loss of flavour which occurs in some of the more delicate; though this also is the result of the slow fermentation under review. In the sweet wines, the same process tends constantly to diminish that sweetness: and hence, the comparatively dry qualities of ancient Malmsey and of Paxaret under the same circumstances. In this class of wines also, the flavour is injured by the same process, or by age: and hence, though age may confer merit as well as honour on Malmsey and Malaga, and generally on the sweet Spanish and Greek wines which have little flavour, by diminishing their lusciousness: it destroys or injures the highly perfumed wines of Frontignan, which can scarcely be drunk too new.

By the same considerations we can account for the benefit which Madeira wines receive in a hot climate, or in a hot cellar. The effect of the heat, and, in the case of a sea voyage, united to the agitation, whose action was considered before, is that of accelerating the imperceptible fermentation, and thus ripening the wine sooner than would have happened in a low temperature and at rest. But it is a mistake to imagine, that this is peculiar to Madeira, or that it is the only wine which can be benefited by this treatment. It is the same for all the Spanish wines, for Sherry and for Port, and it is also true of the better and safer wines of France, of those of Hermitage and the Bordelais. Claret becomes drinkable in a much shorter time in a warm than in a cold cellar; and that is equally true of many more of these wines. But that which some will bear, others will not; and thus many of the wines of France, so far from admitting a high temperature, can scarcely be preserved even in a low one. As to Port, it is a useful piece of knowledge to be aware, that it may speedily be rendered aged by heat. And in this case it deposits its colour, and assumes the marks of old wine to the eye as well as to the palate. One year will thus do that for Port which might have required five or six; but the period of its entire duration is consequently shortened, as might be expected. The effect of heat is indeed such in this case as is suspected by few. In America it is a well known practice to boil Madeira, or to heat it to the boiling temperature, and the effect is that of rendering it good and old wine, when previously harsh and new. The same practice is applicable to Port. If newly bottled wine be exposed to the sun, it begins shortly to deposit, and improves in flavour; and even the rawest wine of this kind may, by heating it in hot water, be caused, in the course of a day, to assume the quality which it would have had after many years of keeping. It is so far from being injurious, as might be imagined, that it is a valuable secret; and, as we believe, one that is but little known to those whose interest it is to give the complexion of old wine to new, and who generally effect this purpose in a fraudulent manner, by putting it into foul and crusted bottles.

It is important, in another view, to consider the effects which follow from a portion of undecomposed sugar remaining in wine. It is supposed to be a means and a test of the security of wine; and the French chemists assert, that as long as any portion

remains undecomposed, such wine cannot run into the acetous fermentation. This appears true only in a limited sense. In Hock, it would seem as if every atom of sugar had vanished, and yet the durability of that wine appears to be endless. If that is not absolutely the case in Claret and Madeira, still these are very durable wines; the most so, after Hock, at least of the dry class. None of these, when of a good quality, ever run into the acetous fermentation. Perhaps this may depend on some peculiar balance of principles which chemistry has not yet found the means of discovering. For, in other cases, it is certain that the chemists in question are under an error; and that the acetous fermentation will come on, though sugar should still be present. This happens in many of the French wines of the lighter kinds. If, in the sweet wines from the grape, that effect does not take place, it is very certain that it happens in the wines made in this country in imitation of them from various substances. In these cases, even sweet wines are found to be occasionally *pricked*, as the technical term is, or vinegar and sugar are coexistent in the fluid at the same time. Nor are even all the foreign sweet wines of the grape exempt from this disease; as must be well known to those who have an extensive knowledge of wines, or of the wine market.

There is reason to believe that the cause of this must be sought as a circumstance which these chemists seem to have overlooked. If the balance of principles in a sweet wine has been perfect, and the process of fermentation has also been complete, and if, in addition to this, these wines have been so carefully racked and fined, that no lee or leaven remains in them, they may be safe, because there is nothing left in them to re-excite a fermentation, or to bring on the acetous stage. But if that is not the case, if any impurity, any leaven in any form remain, the sweetness offers no security against the change into vinegar, or at least against that partial change which constitutes a *pricked* wine. The acetous fermentation may commence and proceed as far as the circumstances allow; and thus vinegar and sweet wine may exist together in the fluid. The nature of the acetous fermentation is indeed very ill understood; as little as that of the vinous; and we are at present incompetent to reason much about it. It is a common opinion that it must be preceded by the vinous; yet this does not appear to be true. Certain mixtures of sugar, leaven, and water, will immediately tend to vinegar, without our being able to detect a previous vinous stage; and this seems always the case when the solution is very weak, or the water in large quantity, provided, of course, there be access of air. It is indeed unquestionable, that in the common process of making vinegar, the acetous fermentation is going on in a saccharine fluid; so that the mixed taste of vinegar and sugar is perceptible until that process is completed. Vinegar can also be produced by passing alcoholized carbonic acid through water, another obscure operation; and in the human stomach it is produced in a very few minutes, when we can scarcely imagine that any previous vinous stage can have taken place.

Management of Fermentation.

When all the favourable circumstances above stated are present, the fermentation begins and passes through its regular stages till there is produced wine, perfect and dry, if the sugar has been thoroughly and accurately proportioned to the other ingredients; sweet, if it has been in excess; and acid, as in Hock, when this substance has been in undue proportion to the other ingredients. The unfavourable circumstances must be sought in the temperature, or in the quality of the fluid. The juice of the grape rarely labours under any defect but the want of sugar, arising from a bad variety of this fruit, from a bad season, or from imperfect ripening. In the latter case, however, there may be added to defect of sugar or excess of water, an excess of acid and an excess of extractive matter.

In the wine countries the defect of sugar is remedied by different expedients. In some, sugar or honey is added to the juice, or must; in others, a portion of the juice is evaporated and added to the rest; and, sometimes, all the juice is boiled before it is submitted to fermentation. These seem to have been the *vina cocta* of the ancients, which, from other circumstances, we know to have been thick and sweet wines, requiring dilution. They could not have been boiled to any consistence after they had become wine, without losing all their properties; and as to wines that were to be cut by a knife, it is plain that we must have misapprehended the meaning of the term *vinum* in this case, as no wine could exist under such a form. To gain the same ends, it is a practice in many countries to dry the grapes partially, by suffering them to remain on the vine; but this is chiefly resorted to for sweet wines, as in the case of Cyprus, Tokay, Lipari, and others. The other expedient for increasing the properties of sugar in the juice is by plaster of Paris, or gypsum, not an uncommon ingredient; and this effect, as well as that of absorbing and destroying superfluous acid, is also partially attained by the use of lime.

The management of the fermentation, supposing the fluid to be perfect, is regulated by the intended nature of the wine. If sweet wine is desired, not only must the proportion of the water be diminished by one or other of the means above mentioned, if necessary, but the proportion of extractive matter or leaven must be reduced, to prevent it from running to the ultimate stage, and producing a dry and strong wine. In this case, the yeast is separated as fast as it rises by mechanical means; as by fermenting in full casks in such a manner that it may be continuously ejected at the bung-hole as fast as it is formed. Should the reverse be desired, or a dry wine be the manufacturer's object, the yeast is suffered to remain on the surface in the vat, that it may be continually returned into the liquor by the internal agitation, or else it is stirred, or rolled in a cask, or in the vat, so as to protract the fermentation. Lastly, If the wine is to be brisk, to retain carbonic acid, as in the wines of Champagne, not only must the proportions of water and leaven be increased, but the fermentation must be conducted in vessels partially closed, and these also must be fully closed before the fermentation is completed. The management of the temperature is easily deduced from the principles already laid down. A deficiency of heat is

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easily remedied by artificial means, by a fire, or by exposure to the sun; and this is sometimes done by heating a portion of the fluid, and then mixing it with the mass. An equal temperature in the vat is also procured by agitation, and when it is necessary carefully to maintain a mean heat, this is frequently done in the wine countries, by surrounding it with straw or other bad conductors, or by other obvious artifices.

On apparently minute attentions of this nature, far more depends than would, on a superficial view, be imagined; and the great superiority of the wines of France above those of Spain, Italy, and Greece, depend often much more on delicacies of this nature than on any difference in the quality of the grape. In wine-making, indeed, more seems to depend on art often than on nature; and it is both to the praise and advantage of the French, that, by these minute attentions, they have contrived to excel all Europe in this art. Italy, Spain, and Greece, with better climates, and every natural advantage, are thus the manufacturers of a thousand detestable wines, which, in the hands of Frenchmen, might rival the produce of that country. The recent improvements made in the Sicilian wines in new hands, are a proof how much depends on these attentions; and those who have drank the nauseous, putrid, acid, and disgusting common wines of Italy and Spain, where nothing is wanting but management and care, will know how to appretiate the value of these.

In conducting the fermentation, some other considerations are necessary, on which some remarks are also required. The first of these is the flavour. That evanescent and delicate property, the *bouquet*, as it is called, depends on attentions no less minute. The flavour is very apt to be dissipated by a violent or a long fermentation, or by an open one; and hence, for the finer wines, great care is required through every stage of that process. It is the same for the brisker wines; as, if this be neglected, this volatile substance, on which their peculiar property depends, may be irrecoverably dissipated. A consideration of the general divisions of the quality of wines will render these remarks more intelligible.

They may be divided into four classes: the sweet and strong; the dry and strong; the delicate and light, which are generally weak compared to the former; and the effervescent or brisk. Malmsey, Tokay, Frontignan, are examples of the first, and the second are peculiarly familiar to England. Hermitage holds an intermediate rank, as does Claret, between these and the third class; of which the lighter Burgundy wines, the white wines of Greece, and those of the Rhine and the Moselle, may be considered pure examples; and, of the last, Champagne is almost the only one that deserves to be named.

If, therefore, the intention is to make either a strong sweet wine or a strong dry one, the fermentation is commenced in an open vat. But, in the former case, it is not suffered to remain there long, as it is in the latter. For the driest wines, or for those which are manufactured for distillation, the fermentation is allowed to expend itself in the vat, and the wine is not tunned till it is made; the completion of the process merely, or the final solar fermentation, being reserved for the cask. In the sweet wines, on the contrary, it is soon removed from the vat to the casks, that it may be more in the operator's power to suspend the process, and thus to prevent the annihilation, or total conversion, of the saccharine matter. In the third class again, in the highly flavoured wines, of which Burgundy may be selected as an example, the fluid is only suffered to remain a few hours in the vat; from six perhaps to twenty, that period varying according to the state of the temperature, the particular quality of the juice as to goodness or strength, and the other views of the manufacturer. This is done to prevent the dissipation of the flavour, which would be injured if not destroyed by an open fermentation. The same practice is followed for the wines of Champagne, though there is here little flavour to preserve; the purpose being, in this case, to secure the power of checking the fermentation by pressure, so as to retain the wine in a low stage of this process, and thus to secure a supply of mixed, or combined carbonic acid, at the period of use or drinking.

Further Precautions in Fermentation.

There is nothing which more strongly distinguishes the bad, or inferior wines of Spain and Italy from those of France, even from those which, from their cheapness, must be considered as belonging to the same class, than the various disgusting flavours which they commonly present. Wines may have bad qualities from other causes,—from the nature of the soil or the grape; but there is far less difference in this fruit in different countries than there is in the care bestowed on the manufacture. To use a short and intelligible term, it is *filth* which is the cause of the bad quality of these wines; filth and neglect in every stage of the process, from the gathering to the pressing, the fermentation and the tunning. In the fermentation, no precaution too great can be used to have all the vessels clean and entirely free from every odour. There is no substance more delicate than wine, nor any one which is so easily contaminated and destroyed by bad flavours, even in the minutest quantity.

The same rules apply to the casks as the vats. New casks communicate the well known flavour of oak, often found in wines, and that, fortunately, is so agreeable a one, that it is often given designedly by means of oak shavings. But in the finer wines, where it would be injurious, it is extracted from the wood by washing, and by hot water and by salt. The more destructive evil of musty vats or casks, so often a cause of the nauseous flavour of the common wines above mentioned, is remedied by scraping, by washing with boiling water, and, most effectually, by firing or charring the insides; while staves which are injured deeply are replaced by new ones. Hot lime and water are also used for the same purposes.

Another precaution is that of removing all the insoluble matter, of whatever nature, during every stage of the process; and from this neglect it is also that the great mass of bad wines is produced in those countries where this art is neglected. Thus the seeds are always to be removed as fast as they rise to the surface, as they both render the wine harsh and communicate a bad flavour. The same is done with the husks when they have performed their duty in giving out their colour. It is most peculiarly ne-

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cessary to be watchful over these, lest they should become moulded or musty; whence often arises that taste which resembles that of what is called *corked* wine; a disease also arising from a bad cask, and often attributed wrongfully to careless bottling. In the finer wines, a single musty seed or husk will ruin a whole tun. In transferring the wine from the vat to the cask, or from one cask to another, whether by drawing off or pumping, care must be taken not to disturb the sediment; and more especially still, to separate any of the scum which may be on the surface, as this is always in danger of becoming musty, more particularly where it is most injurious, that is in the lighter and finer wines.

When the quantity of the fermented fluid is considerable, the remaining wine, which adheres to the solid matter, is separated by the press, and made into wine of an inferior quality, either for use or distillation. That refuse is also subjected to distillation with water, in some cases; sometimes, by means of water, it is converted into vinegar, or used for the manufacture of white-lead or of verdegris; or, lastly, formed into cakes with the other refuse of the first pressing of the grapes, and used for feeding cattle.

Management after Fermentation.

If, after the wine is made and tunned, it were suffered to go on fermenting, it would, in many cases, be destroyed. This, it has already been seen, does not easily happen in the sweet wines, where a large portion of the saccharine matter remains unchanged, though even these are not absolutely exempt. Nor does it very easily happen in the stronger dry wines. Yet it does happen to all, and is almost inevitable in the light still wines, and in the brisk ones, whatever the strength or sweetness of the latter may be. Champagne would quickly become vapid, Burgundy would become stale and sour, and Claret would become vinegar. For though the natural progress is supposed to be from the vinous to the acetous stage of fermentation, there are phenomena in practice which show us that we are yet imperfectly acquainted with the exact nature and varieties of fermentation. Champagne, for example, becomes mucilaginous and flat; while, though Burgundy becomes acid, it is scarcely possible to make it pass to the exact state of vinegar.

Yet the tendency to the acetous stage must be considered as general,—for want of a better expression; and, on this view, the management after the great fermentation is regulated. If it is suspected that even intended sweet wine has been over wrought, boiled must or sugar is added to it; and thus, in the tedious fermentation of the cask, it is secured or restored. But it must be remarked, that if the acetous stage should have commenced, that addition would only serve to accelerate and determine it. The remainder of the general management consists in regulating the fermentation of the cask by the general principles before laid down; that is, if the wine is incompleted, it is not suffered to rise to the bung-hole, so that the new leaven, which is disengaged, may fall back again and protract the fermentation; while this is also aided by heat, by stirring up the lees, and by agitation. If the reverse be the case, and that it is necessary to check the secondary fermentation, then a cool temperature and rest are adopted; while, as fast as the wine wastes, it is kept close to the bung by fresh additions, that so the disengaged leaven may escape. Some of the other requisites to the completion of wine will fall better into another section of this little essay; but the process of sulphuring belongs to the second stage of management, as well as to the final operations of the manufacture.

Fining, Sulphuring, and Clarifying Wines.

However vulgar and mechanical the process of sulphuring may appear, it is a refined chemical operation, the practice of which was long known before the theory, however discovered; and the theory of which, in a scientific and rigid view, is not very well understood even now. It has been already shown, that the process of fermentation has a perpetual tendency to continue as long as all the requisites are present, and, more particularly, as long as there is present that peculiar and obscure substance, the extractive matter, or leaven, on which it mainly depends. If, also, this substance has been entirely separated in the two forms of yeast and lee, the process terminates naturally; the produce being dry or sweet, according to other circumstances now understood. But if any portion of leaven remains in the liquor, then the acetous, or some similar stage, may come on, and the wine will be destroyed.

The processes of racking and mechanical separation just described, are all intended to separate this matter: and whenever the wine remains turbid, it is always in danger, because the fermentation may at any time be renewed. But often these operations are insufficient to disengage all the leaven or lee; as much of it not only continues mixed, so as to produce the turbid state, but the extractive matter itself, which has not been brought to this insoluble form, remains combined with the fluid.

The merely turbid state is remedied by the process called fining, which precipitates all the insoluble or disengaged lee and leaven that will neither subside nor rise; thus removing one part of the hazard, besides communicating that brightness and beauty which is demanded in all wines. That brightness, therefore, is more than a beauty, since, without it, there is no security,—at least in the finer and lighter wines. Various substances are used for this purpose, and the action of many of them is very obscure. They are either chemical or mechanical. The mechanical substances are sand and gypsum, both of which have the property of precipitating the insoluble matter; while the latter also absorbs water. Beechwood chips are sometimes used for the same purpose; but the mode in which these act is not known. But the matters chiefly in use are chemical ones, gluten and albumen. Of the latter, eggs and milk are both used; but the former are preferred. Of gluten, isinglass alone is used; for, from some causes hitherto undiscovered, the gluten of terrestrial animals, or common glue, does not produce this effect to the same extent that it is obtained by the glue of fishes. It is also usual to adopt albumen for the white wines, and gluten for the red; as the former is found to precipitate much of the colour from these last. The proportion used is very small, an ounce of isinglass being sufficient for a hundred gallons. To these chemical matters we might have added starch, gum, rice, and blood,

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but they are very little used. The action of the albumen appears more mechanical than chemical; becoming coagulated, and then entangling the dust, if it may so be called, which is suspended in the fluid, in the same manner as it would purify muddy water. In the case of the gluten, however, a new chemical combination is formed with the tannin of the wine; and the produce is that well known substance resembling bird-lime, which is the basis of leather. Hence, also, fining diminishes the astringency of red wines.

Presuming that one of these substances has been introduced, the fluid is strongly agitated and suffered to repose till clear, when it is again racked into a fresh cask. It is found very important to select for this purpose dry cold weather, and, as is particularly remarked, north-east winds. From some mysterious cause, in close weather, and fogs, and southerly winds, the precipitated matters rise again, and defeat the objects of the operation. The other precautions are those of using a syphon instead of a cock, as affording greater security; or, what is now used in all the best French manufactories, blowing off. This is performed by a condensing engine, as in the drawing of porter, and thus access of air is prevented. This is very important where fine flavoured wines are concerned, as it is in brisk wines; because the carbonic acid which would thus be lost, carrying away also a portion of the alcohol or strength of the wine, is thus preserved.

But the leaven held in solution cannot be separated in this manner; and for that purpose recourse is had to the process of sulphuring. The most common and the simplest practice in this case, is to fill the proposed cask into which the wine is to be racked, with sulphurous gas, by burning matches in it till full. The wine, being then introduced, becomes turbid, and, after the necessary time, it is found as before. Should the fermentation still be renewed or dreaded, this operation is repeated as often as it may be necessary. If, as in the case of some of the Bourdeaux wines, the quantity of leaven in the wine is so great, that it cannot be overcome in this manner, the combustion of the sulphur within the cask is repeated at intervals during the process of filling it. But it is also a practice in that country to impregnate with sulphurous acid a quantity of wine, and this substance or mixed fluid, called *Muet*, is reserved for adding to those which may require it; by which means the efficacy of the operation is better ensured.

The theory of this practice seems, to a certain extent, simple. The sulphurous acid, or possibly its oxygen, unites to the extractive matter, or the soluble leaven, and renders it insoluble, as happens in the act of fermentation itself; and thus it becomes capable of being separated by the mechanical processes of racking and fining. It is for this reason also, that sulphuring is largely used for the sweet wines, to ensure their preservation in that state. It has been said that manganese, and other substances, containing much oxygen, will produce the same effect; but the cheapness and simplicity of the common process renders other expedients unnecessary.

On the further Processes in Wine-Making.

Supposing wines of any class to have thus been obtained, there is yet much more to be done before they become the wines which we know in our market. The processes in use for this end, to make marketable wines, are badly distinguished by the term medication, as they are of various natures. There is a great deal of wine, indeed, which can scarcely be considered as strictly natural; though it is a common prejudice that all wines are so, except when fraudulently mended, or altered, or mixed. It is difficult, indeed, to draw the line between what may be considered fraud and what is legitimate; and certainly by those who expect that all wine is to be what it is commonly thought, the mere produce of the grape, and of one process on one grape, every subsequent process may be esteemed a fraud. We must here limit ourselves to some of the most important and remarkable operations, as the whole would run into a very long detail.

Mixing Wines.

The simplest process is that of mixing different wines together, whether of the same quality or country, or of different ones. In either case, this practice may sometimes be considered fraudulent, and, in the latter, especially so. But, in a degree, it is inseparable from the nature of the manufacture, and the mode in which it is conducted. The larger makers, or the capitalist on the spot, buying in small lots from the petty manufacturers, is obliged to adopt this practice, partly to ensure a certain quality, and partly for the purpose of remedying those that are defective, by the addition of better ones. He must often also have recourse to the same expedient, and for the same reasons, when he is himself the manufacturer.

The mode of performing this operation, which requires great experience and judgment, is to select, first, that period of the year in which the wines show a disposition to renew their fermentation, which is in the spring. They are then said, in English, to bear the *fret;* and hence the operation is called fretting-in. It is only thus that a new and *fine* wine can be produced. The operation of mixing different wines, in all cases, disturbs both, so that they become foul. They also tend to ferment again, till a new balance of all their principles is produced; and thus it is expedient to accelerate and determine this fermentation, so as to form a proper compound, without which the new wine would be perishable. After this, also, it becomes necessary once more to have recourse to sulphuring, fining, and racking; and not till all this has been gone through is the wine completed. In the Bourdeaux practice of mixing Clarets, the Muet or sulphured wine is sometimes added at the same time, where the wines, being of very discordant qualities, a dangerous fermentation might be excited.

In the wine countries, it is usual to cultivate particular grapes or wines, rough, or coloured, or astringent, or high flavoured, for the mere purpose of mixing with others; so far is this art from being so simple as is commonly imagined. In many also it is a practice to import the wines of one country to mix with those of another, and thus to suit the taste of purchasers, or obtain other ends. This practice is

pursued even by the importers into Britain; and, as we need not say, opens a door to endless frauds, while it may also be innocent. Thus, in this country, as well as in Portugal, the wines of Spain, Alicant, Barcelona, and so forth, are mixed with Port wines; as are the cheaper Clarets of the south of France, and some other of the strong flavoured wines of that country. In a similar manner, the wines of Fayal and the Canaries are manufactured into Madeira, as are those of Sicily; and thus, too, Sherry is largely compounded out of many of the wines of Spain and Portugal, and of the islands of the African coast.

But the most extensive operations of this nature are carried on at Bourdeaux with the wines which we call Claret; not one-thousandth part of which are of a good quality, or unmixed in some way, and the one-half of some of which, perhaps, are not French but Spanish wine. The following statement, while it is curious in itself, will illustrate this. In the year 1814, the total quantity of the Clarets, or Bourdeaux of the first class, was as follows:—

	Tons.
Chateau Margaux	80
Latour	70
Chateau Lafite	80

In the second class it was thus:

		Tons.
Margaux de	Madame Derauzan	60
	M. Chevalier	25
	M. Monterison	25
	M. Montalambert	25
St Julian	Leoville	80
	Laneze	70
Pauillac	M. Depichon	60
	Brame Mouton	80

We cannot afford room for the remainder of this statement, comprising the produce of the fourth and the fifth qualities; but it is plain, that very few of those persons who imagine that they are drinking the first growth of Bourdeaux wines, can even be drinking the second.

The first growth of Claret, it is thus seen, amounts only to 230 tons for an average; and that, even of the second, is only 425: a fraction, indeed, in the consumption of Europe. But, in the third class, of which we cannot afford to give the details, there are 1061 tons, and in the fourth, 825, making a general total of 2541 tons. Besides this, there are other inferior wines which do not enter into the enumeration; and it is by mixing the greater number of these in various proportions that the market is supplied; it being necessary to reserve many of the better wines to render the others saleable.

We must however remark, that, among the districts which produce the inferior wines, such as those of the Bas and the Petit Medoc, a few farms produce small quantities, of a quality equal nearly to the good St Julian or Lafite wines; and these add to the bulk of the better kinds, being generally reserved, and sold at high prices. In the district Medoc, the seat of the better wines already mentioned, there are besides the third and fourth classes, six or eight kinds of wine known by the names of *Gros Bourgeois*, *Petit Bourgeois*, *Artisan*, and *Paysan;* and these are manufactured, with others, for the English and Irish markets chiefly, by means of Spanish wines,—by mixing with the strong wines of Benecasto and Alicant. The same is true of the Grave wines.

This is the great mixture, in fact, by which the market is filled to almost any extent with Claret wines, so called; and these mixed wines are almost the only ones we drink in this country. If that be a fraud, it must be remembered also that such is British taste in wine; and that Claret is in general esteemed here only in proportion to its strength. Of the stronger and finer wines there is not enough for even our consumption; and, as we must have them strong, they are thus made such by this process. That effect is also obtained, however, by some of the south of France wines also; by those of Côte, which are used for mixing with the weak Medoc and Grave wines, for the British market. This is the case with those of Queyries, such as Monferrant and Bassens; and those of Palu, such as Macaw, St Romain, Codillac, St André, Lugon, and many more.

Mixture of Brandy.

The French wines of which we have been speaking, will not endure to be rendered stronger by means of brandy. The property of this substance, thus mixed, is to decompose the wine in process of time; causing the extractive matter or mucilage to be deposited, as well as the colour, as is daily seen in Port wines, and thus diminishing their powers of duration. At the same time, it destroys their lightness and flavour; that peculiar indefinable delicacy well known to drinkers of good wine, but quite imperceptible to British drinkers of Port. In a certain sense, we may consider that it is only the bad wines which will bear this medicine; those which have no flavour of their own, and whose whole merit already is their strength. What sort of a compound is made of a weak wine with brandy ought to be known to those who drink what is called Lisbon wine. But a depraved taste has rendered it necessary to our nation; and thus it is largely used, even in those wines of Portugal and Spain, of which the chief fault is that of being too strong already. We may thank the Methuen *Treaty* for being condemned to drink what Mr Pinkerton calls wine fit for hogs only. This mixture is performed in the same manner, at the period of fretting; and the proportion is regulated, partly by the taste of the consumers, and partly by the badness of the wine. As it must have a certain strength, the worst wines require most; and hence, whenever we taste the brandy in wine, we may be sure it is bad. It is a taste sufficiently perceptible to those who know what real wine is.

Flavouring of Wines.

Many wines have so little flavour naturally, that they can scarcely be considered to possess any. There are few, indeed, that possess this quality in any great degree; and, of these flavours, a large proportion is bad. Wines so highly perfumed by nature as Hermitage and Burgundy, are rare; indeed, these are almost the only examples; and, after them, we may consider the finest Clarets, and then the finest of the Rhine wines. The sweet wines which possess it are well known; and these also are but a small part of

the total number in this class; being almost limited to Paxaret and the Muscat wines, among which Rivesaltes stands first. Constantia has rather a taste than a flavour; and what the ordinary sweet Spanish wines possess is rather bad than good; though, like the taste of Sherry, and Porter, and Olives, they may become agreeable by habit.

Excepting these cases, and a few among the Italian wines, which we cannot afford room to detail, many of the flavours found in wines are communicated by art; and this forms part of the business of the manufacturer and merchant. Much of this is a secret, but some of the substances used for this purpose are known. The taste of Greece is now, as it was in ancient times, to perfume its wines with turpentine—the *vina picata* of the ancients; and this is effected by putting turpentine or rosin into the casks. In Britain, our Chivalrous and Baronial ancestors perfumed their wines with every strange ingredient that can be imagined; but that was the age of spicery and perfumes; and he who eat cinnamon with his pork, might drink ambergrease in his wine.

The flavour of Madeira is nothing; but that which we know is given by means of bitter almonds, and, we believe, of sweet almonds also; and the same practice is followed for the wines of Saint Lucar. That which is called the *borrachio* taste in wine is for the most part that of the tar with which the seams are secured. In Sherry, the flavour seems produced by the destruction of the acid, the consequence of the lime used, and possibly by some other action of that substance on the fruit. One of the most common ingredients used for flavouring wines is oak chips; and from this the wretched Lisbon wines acquire the little taste they have. Orris root is also a common ingredient: and the high flavoured wine of Johannesberg is imitated by a proportion of rose water. The orris root gives a very agreeable flavour, and is used in France; and there, also, it is the custom to use raspberries and other highly perfumed fruits. A very agreeable flavour is also said to be produced by wormwood. The flowers of the vine itself are also used for the same purpose, their smell much resembling that of our mignonette. This last is an ancient practice in Egypt.

The method of gaining this end requires some delicacy and attention. In particular, care is taken that it be not overdone. As the full fermentation would destroy the more volatile flavours, these substances are only introduced towards its decline. In Madeira the nut cake is put into the cask. Flowers are suspended in a net or cloth, either in the fluid or the vacant part of the cask, and thus a small quantity of raspberries communicate a very considerable flavour.

Colouring of Wine.

The colouring of wine is also part of the business of the maker; because colour is, in a good measure, a matter of fashion and fancy. Some grapes contain naturally very little colour, while that of the Claret vine, and many of the grapes of Spain, are highly charged with the colouring principle. We already explained that the colour was contained exclusively in the husk. These latter wines are often, therefore, selected and reserved for this particular purpose; and it is also a practice to use the dyeing woods, logwood and Brazil wood, for obtaining the same end. The elder berry, which is full of colour, is also resorted to; and in Portugal it used to be extensively cultivated for the purpose of dyeing Port wines. When white wines are thought too pale for the market, they are coloured browner by means of the well-known ingredient burnt sugar; and the chips of oak also produce the same effect. By some means also iron finds its way into some of the French wines, and thus, on exposure to air, they become black. This unpleasant effect is not unusual in the sweet wines from the south of France.

Briskness of Wines.

This property relates almost exclusively to the wines of Champagne, and it is one that may err in excess or defect. It is already apparent, that it is the produce of an unfinished fermentation, and, therefore, a due degree of it must depend mainly on the proper management of this process. It is secured by bottling at the proper season, March, and before the fermentation is exhausted; and, if in danger of excess, it is restrained or diminished by racking, or decanting, and sulphuring. But it happens not unfrequently that it fails altogether; either from accident in the management, or a bad season; from faults in the fruit, or fermentation carried too far, or a weak wine exhausting itself unexpectedly. In this case the remedy is to introduce sugar, not only into the casks but into the bottles. In the first case, the fermentation is renewed, and the wine may thus become legitimate and good. In the other, the effect is far different, and not good; and hence it is that all the very sweet Champagne wines are bad or indifferent. These are, in fact, a mixture of wine and sugar, rather than proper wine. And, in this case, the effect of the sugar is, not to produce a new fermentation, but to disengage the carbonic acid of the wine; as a salt or any other soluble substance would do, by a superior affinity. To gain this end, the solid sugar is corked up in the bottle; so that the disengaged gas is retained under the pressure of the cork, ready to fly out whenever that is removed. Thus Champagne, which has been destroyed by age, is rendered, at once, both sweet and effervescent; and this, however convenient a secret it may be to the possessor, is but a fraud, and a very common one too.

Acidity of Wines.

The acidity, or the pricked taste of wines, is a fault which, perhaps, ought never to be corrected, as, in this case, the wine is generally spoiled. This nevertheless is done, and sometimes to a considerable extent. Acidity arising from tartarous acid, or even from malic acid, if that really be the acid in wines which is not tartarous, may be a virtue and a quality; as it is very remarkably in Hock. But it is often thought otherwise, even when it is the natural property of the wine, arising from its own native acid, and after a correct fermentation. In this case, means are applied to remedy it, as a disease in the wine. In the manufacture of Sherry, it was already remarked, that lime was used to prevent it, and this is also applied in other cases, where tartar is in excess, as the tartrite of lime is insoluble, and can be fined down and separated by racking. It has been the fashion to use lead, metallic lead, for this pur-

pose; and, in France, it was formerly used largely in the wines consumed in Paris. It was then discovered, and the act made penal; and, if not abandoned entirely, it is less used at present every where. That this is a poisonous substance is too well known. But that has been overrated in this particular case. The tartrite of lead, like that of lime, is insoluble; so that, after the lead had done its duty, it was discharged by racking and fining. Had this not been the case, all Paris, at the time we speak of, must have been poisoned. Yet it is a substance that ought not to be used; because, in an acid wine, ascescent from fermentation, it might produce either white lead, or subcarbonate of lead, or else sugar of lead, acetite; both of them poisons, if in different degrees.

For the acidity of wine from the commencement of the acetous fermentation, there is no proper remedy. It may be checked, if taken in time, as it would be prevented, by careful sulphuring. Here lead is highly pernicious; and it need scarcely be said, that to add sugar of lead, as has been done from ignorance and fraud united, is to add a poison without even obtaining a remedy. Chalk and lime may be used with impunity. Yet neither can these, and far less alkalies, be used to such an extent as to cure the disease; as they unite to the other acids, and also decompose and destroy the wine. To prevent it as far as possible, when commenced, a low temperature, and careful exclusion from the air, are necessary. But it must be remembered that air will find access, not merely through cork, but through sealing-wax, and, indeed, through all rosins also; and thus there can be no complete security; the best being that of placing the bottles on their sides, so that the fluid itself becomes its own cork. The Italian practice of using oil is thus far safer; but it is balanced by its various inconveniences.

Ropiness of Wines.

Ropiness is a disease almost peculiar to the wines of Champagne, and its chemistry is very obscure. It is not a destruction of the wine, although it materially injures its flavour and other qualities. It occurs in this wine, from the quantity of extractive matter which it still contains, and which is that by which the fermentation is maintained. It is conceived to arise from the action of oxygen on this substance, converting it into a matter analogous to fibrine, instead of changing the whole into vinegar. Thus it resembles the mucilaginous deposit of vinegar called the *mother*. In the bottles, it may be often cured merely by heat; by exposure to the sun, or by immersion in hot water. When obstinate, it is remedied by uncasking, and by agitation; by exposing the fluid to the air. It is said also to be removed by a small quantity of any vegetable acid, as it also is by sugar; but when on a large scale, it requires the process of fining.

Bottling and Cellarage of Wines.

It is held essential by the French, who are our chief teachers in every thing that relates to wine, that a wine cellar should not only be dry, but preserved in a very uniform state of temperature, as near to the mean annual heat of the country as possible. We have already shown, however, when this rule may be usefully departed from, for the purpose of accelerating the ripening of wines. In the delicate wines of that country, however, the rule still holds good; and very conspicuously too with regard to the wines of Burgundy and Champagne. It is equally true of the finer and lighter Italian wines. The wines of Spain and Portugal seem to defy every thing. It is also held by the French most essential, that a cellar should not be subject to the agitation of carriages; the reason of which is plain enough; and that it should be free of bad smells. As to moisture, however, we must remark, that, like heat, it seems to accelerate the deposition and consequent ripening of Port wines. On bottling, we need say nothing; only let it be remembered that corks cannot be too good, but that no precaution will absolutely prevent all communication through a cork, however secured and sealed.

Making of particular Wines.

The rules which we have thus given are all of a general nature; and though some of the particular distinctions in the modes of making the several classes of wine might be understood from them, there are yet a few niceties to be explained; while an example from each of the four classes into which we divided wines, will render the subject more intelligible.

Champagne Wines.

The attentions required in Champagne wines are perhaps the most minute, and the most complicated, and they therefore stand most in need of being detailed. Champagne is a late country, and it frequently happens that the frosts have arrived before the grapes are ripe. Of course, it is an imperfect vintage. Yet, in a certain sense, this is an advantage; while it has also condemned that country, in a great measure, to limit itself to this particular class of wine. A very brisk wine is not easily secured from grapes absolutely ripe; and thus the half-ripened fruit of this district is brought into use. Yet the best of these wines, the finest class of Sillery, rarely seen in this country, is made from the ripened grapes. And hence it is, that the best of the Champagne wines are those which are least brisk or violent, and that great violence is a characteristic of the inferior kinds. When there is violence and sweetness both, we may easily conjecture what the wine is; and in those, as might be expected, there is no flavour.

The finest wine is thus produced here by a very light pressure of the grapes; in which case only the ripest give out their juice.

It is held necessary to gather them when the morning dew is off, to prevent water being added to the juice. The next pressure, and the least ripe grapes, are reserved for the inferior classes. When the juice is poured into the vat, it remains one night only, the seeds being carefully separated. In all cases also, the greatest care is taken to separate damaged grapes or rotten ones; and it is as much from this neglect as any thing, that the common Italian wines are so bad. If the Champagne is to be red, the fermentation is suffered to proceed on the husks a little longer, for the purpose of extracting the colour; and according to the length of this process, we have the *oeil de perdrix*, and the pink and red wines. But as we remarked before, this injures the flavour, as all good judges of Champagne know.

When the liquor is transferred to the cask, the discharge of yeast at the bung-hole is encouraged for

ten or twelve days; and when the fermentation has become moderate, the bung is put down, and a hole is made by its side. This hole is occasionally opened to give vent to the air, for a space of eight or ten days; when no more air is discharged, fresh wine is introduced, so as to keep the cask constantly full to the bung-hole. This operation is continued when necessary, till the end of December, when the wine generally becomes clear. It is then racked into a fresh cask, and fined. After this, it begins to ferment again, losing a portion of its sweetness, and improving in quality. If too sweet, it is not decanted and fined till the fermentation has been renewed by agitation. As the fineness of this wine is one of its essential qualities, and one difficult to obtain, on account of its perpetual fermentation, it is racked and fined a second time, and thus it remains till March. In March it is bottled; yet still it ferments, though corked, and again it begins to deposit. In the best wines, it thus remains from fifteen to eighteen months in the cellar, when it is bottled over again, and is then marketable. The inferior kinds are seldom bottled twice; but an expedient is used instead, to get rid of the sediment. For this purpose, the bottles are ranged in frames with their necks downwards; and when the sediment has been collected in the neck, the cork is dexterously drawn, and again replaced, after which the bottles are filled and completed for the market. There are varieties also in this general process, such as that of suffering the wine to remain in the cask for a year or more on its lees; but we need not enter into these collateral details.

Burgundy and Bourdeaux Wines.

There is little difference in the practice of Burgundy, except what refers to the retention of the carbonic acid. All else is the same; but great care is taken to clear these wines of their lees, as, from their extreme delicacy, they would soon lose their flavour, and also become sour. In the practice of Bourdeaux also, the first stages of the process are the same, excepting in as far as a longer fermentation in the husks is used to extract the colour from the red wines. But there is a difference as to the process of sulphuring, which is largely used in these, in the manner as already described. The red wines of Bourdeaux are racked about the end of March or the beginning of April, but the white in December; and in all these wines, great care is taken in all those circumstances which relate to cleanliness, however rude the people, and the operations may appear on a superficial view.

Italian Wines.

In the drier Italian wines, the must is allowed to ferment completely in the vat. In some vineyards, a quantity of selected and half-dried grapes is thrown into each tun when the wine is finished, so as to give it sweetness, and prevent the hazard of its running to the acetous stage; a rude and a bad process. In the manufacture of Florence wine, the must is withdrawn from the vat as soon as the head is raised, and the wine is transferred to a cask, where it is only suffered to remain thirty-six hours, when it is again decanted into a fresh cask at the end of a few hours, and so on, until it is clear and marketable. Thus it is completed in a short time, by little more than the process of racking.

Sweet Wines.

In different countries, the practices used for procuring the sweet wines vary; but they will be found to depend on one or other of the principles already laid down. In Italy, as in the making of Florence wine, the fermentation is quelled by repeated racking and shifting. Thus the other processes are partly or entirely saved. But it is necessary that very sweet and rich grapes should be used if this process is to be followed. To ensure sweetness, on the principles formerly laid down, the grapes of Tokay are partially dried before they are used; and this is also done for the wines of Cyprus, and for some of those of France and Spain. The remaining processes, consisting in sulphuring, &c. need not be detailed again, as they are nearly the same in all countries.

Port, Madeira, &c.

In Oporto, for the dry wines, the practice is to carry on the complete fermentation of the must in the vats. The wine is then introduced into large tuns, capable of holding twenty-five pipes each, and at this stage, the brandy is added at the discretion of the maker. In Madeira, the second or insensible fermentation is effected in pipes, and, at the end of three months, the wine is racked, when a certain portion of brandy is added. In both these practices, it would seem as if the union of the brandy with the wine was less perfect than it might be rendered by a different management of this part of the process. Hence, probably, it arises, in a great measure, that the taste of brandy is so sensible in many of these wines. In the best, the quantity is said to be about a twentieth part; but, in the worst class of Port wines, it seems sometimes to amount to a fifth or more. The process followed in making Sherry is rather more complicated. The grapes, in this case, are first slightly dried, and then sprinkled with quicklime. They are then wetted with brandy when introduced into the press, and a farther portion is again added to the must before fermentation. It is highly probable that, by this practice, the brandy is more perfectly combined in the wine, and the fluid rendered more uniform; and hence also, probably, it arises, that the taste of brandy is not to be perceived in genuine Sherry, though often found in those baser imitations which are manufactured from the tasteless wines of the Canary Islands, and of other parts of Spain. The remainder of the process for Sherry consists in racking repeatedly at intervals of a month or two; fresh brandy in small quantities being added at each stage of this process.

We may, in conclusion, remark, that in the attempts to make wines in our own country from native fruits, the same rules are of universal application, and that an attention to them would render these domestic processes more complete than they now are, and the results more valuable. In Britain, also, it is easy to make very good wine from immature grapes, by the addition of sugar in the necessary proportions; and these can be procured in almost any season, so that this might even become an object of a petty domestic commerce. Nor is the manufacture limited to the fruit alone, since the leaves and tendrils, by infusion, admit of the same treatment, and with the same results. Very tolerable wine, perfectly resembling the wines of France, can thus be made, and at an expence of little more than the very moderate cost of the sugar. (P. P. P.)

Worcestershire.

Boundaries and Extent.

WORCESTERSHIRE, an inland English county in the Oxford circuit, and nearly in the centre of the kingdom. It is bounded on the north by Staffordshire and Shropshire; on the south by Gloucestershire; and on the east by Warwickshire. Its figure is very irregular; and it is remarkable for having several detached portions scattered about the neighbouring counties, which make it difficult to be accurate in its dimensions. It may be stated as about thirty miles in length, and twenty-four in breadth, and to be 736 square miles, or 502,040 acres in extent.

Population.

According to the census taken in 1821, it appeared that the number of houses in the county were 35,950, inhabited by 39,006 families; of whom 14,926 were chiefly employed in agriculture, 18,566 in trade, manufactures, or handicraft, and 5514 were comprised in neither of those classes. The whole number of persons was 184,424; of whom 90,259 were males, and 94,165 females. The rate of increase between 1811 and 1821 was 15 *per cent.*

Face of the Country and Agriculture.

There is a soft beauty on the face of this county when viewed from any elevation, such as the Malvern or Abberley Hills, which is highly gratifying. From such spots the state of its cultivation appears to great advantage, as there are no parts of any considerable extent so barren or neglected as to be destitute of an agreeable and profitable verdure. With the exception of those hills, the former of which rise to the height of 1440 feet, the whole county consists of gentle undulations, wholly inclosed, well wooded, and intersected by the great rivers Severn and Avon, and their several tributary streams. The abundance of orchards of pear-trees and the scattered hop plantations give a peculiar richness to the autumnal scenery. Even the poorer parts of the county, between the towns of Droitwich and Bromsgrove, have of late been cultivated; and, though they do not rival in beauty the vale of Evesham, they are far from the aspect of sterility which they exhibited twenty years ago. The farms are generally of small extent, from forty to three hundred acres, and the cultivation is generally well conducted. The arable land, which, in the rotation of crops, produces artificial grasses, is estimated to be 360,000 acres; the permanent grass land 100,000 acres, and the woods, wastes, rivers, roads, sites of towns, and gardens, 40,000. The crops of wheat, barley, and especially of beans, are more productive than the average of England. Hops are extensively cultivated, and the pear-trees are so abundant and so productive as to afford perry for the common drink of the labourers in agriculture. There is no breed of cattle peculiar to Worcestershire, as it is found more profitable to buy oxen and sheep in a lean condition from poorer districts, and to fatten them in Worcestershire, than to breed them on its rich soil.

Rivers and Canals.

The great rivers Severn and Avon are both navigable, the former to an extent of near two hundred miles from its mouth, and the latter to Stratford from its junction with the former. The Severn abounds with salmon, shad, and lampreys, though none of those delicious fish are ever known to ascend the Avon. The other rivers are, the Stour, the Salwarpe, the Ledden, and the Rea. This county has partaken largely of the benefit communicated by internal navigation. The canals are, the Trent and Severn, the Droitwich, the Worcester and Birmingham, the Dudley and the Leominster. The town of Stourport has risen into importance since the extension of canals, and exhibits a large maritime town in the centre of the kingdom, connecting its various productions in a focus, and distributing them where needed.

Manufactures.

The manufactures of the county are various and extensive. Worcester produces great quantities of gloves and some of the most beautiful porcelain. At Stourbridge are many glass-houses. Dudley is employed in the iron-trade, especially in making nails. At Bromsgrove some table-linen is made, and small articles of iron, such as needles, nails, and tenter-hooks. Kidderminster has attained much opulence by its manufactures of carpets and of goods composed of silk and worsted, and of silk and mohair. At Evesham there is much oil and oil-cake made from linseed. The productions of the county are easily conveyed to London, Liverpool, Bristol, or Hull, by inland navigation; and, from this state of things, its commerce is very extensive.

Salt Springs.

The salt made at Droitwich supplies nearly one-half of England with that indispensable article. The duty collected there before the abatement of the tax amounted to more than L.1000 *per* day. The water, from which the salt is made by evaporation, is more highly saturated than any other that has been discovered. Researches in the bowels of the earth have shown that a river of salt water, about twenty-two inches in depth, runs about 250 feet below the surface. Immediately above this subterranean stream is a bed of gypsum 130 feet thick. When this stratum is penetrated by the borer, the spring rises to the surface, and yields a never-failing supply of water, so fully saturated, that no more salt can be dissolved in it. The springs at Droitwich hold in solution about one-fourth of their weight in salt; no other in England holds more than a ninth. The subterraneous river runs over a bed of rock salt, whose thickness has not yet been ascertained. Besides the springs at Droitwich, other mineral springs are found at Malvern, which are resorted to for their healing properties, as well as for the pure air of the district. The combinations of the wells are carbonate of soda, carbonate of lime, carbonate of magnesia, carbonate of iron, sulphate of soda, and muriate of soda.

Titles and Representation.

The titles derived from this county are, Marquis of Worcester; Earl of Beauchamp; Viscount Dudley and Ward; and Barons Foley, Lyttleton, and Northwick. Two members are returned to the House of Commons by the county; two each from Worcester, Droitwich, and Evesham, and one from Bewdley.

Towns.

The most considerable places and their population are, Worcester, 17,023; Dudley, 18,211; Kidderminster, 15,296; Bromsgrove, 7519; Stourbridge, 5090; Bewdley, 3725; Evesham, 3487.

Seats.

Among numerous seats of noblemen and gentlemen in this county the most distinguished are, Madresfield, Lord Beauchamp; Hagley, Lord Lyttleton; Croome Court, Earl of Coventry; Northwick,

Worcestershire || Wurtemburg.

Lord Northwick; Hartlebury Castle, Bishop of Worcester; Dailsford, Warren Hastings; Ombersley Court, Marquis of Downshire; Hewell Grange, Earl of Plymouth; Hanbury Hall, John Phillips; Overbury, James Martin; Winterdyne House, William Moselay; Westwood House, Sir Herbert Packington; and Whitely Court, Lord Foley.

See Nashe's *Survey of Worcestershire.*—Pitt's *Agricultural Survey.*—Brewer's *Worcestershire.*

(w. w.)

Progress of this State.

WURTEMBURG, a kingdom in the interior of Germany, formed within the few last years out of the ancient duchy of the same name, with the addition of several smaller territories progressively combined with it, in the reigns of the two last Sovereigns, by an accommodating policy, and a sedulous regard to their own interest during the progress and conclusion of the French Revolution. By an armistice made with France in 1796, all the territories on the left bank of the Rhine were ceded to that power; but by the opportune peace of Luneville in 1801, and a separate treaty which followed as a consequence of it, Wurtemburg was raised to the dignity of a grand duchy, and obtained several districts which had been either portions of small independent states or ecclesiastical dominions. Among these were the cities of Heilbron, Gmünd, Hall, Rothweil, and some others, with the districts around them. The whole of these acquisitions extended over 633 square miles, and contained 115,000 inhabitants. The former territory on the left of the Rhine being only 165 square miles, with 50,000 inhabitants, Wurtemburg was considerably augmented. In December 1805, in consequence of the part taken in the war between France and Austria, the kingly dignity was assumed, and the possession of several other portions guaranteed by the former power. These acquisitions comprehended several districts on the Danube, whose inhabitants were estimated to be 158,000. In 1806, when the Confederation of the Rhine was formed, Wurtemburg joined it, and stipulated to contribute to its support 12,000 men; in consequence of which, other considerable additions to its territory were made. Several exchanges of dominion took place with Baden and Bavaria; but rather for the sake of rendering the limits more distinct than to increase possessions. The part taken by Wurtemburg in the wars declared by France against Prussia in 1806, and against Austria in 1809, led to a further augmentation; and by choosing the precise moment for deserting the cause of Buonaparte in 1813, the King was enabled, at the subsequent Congress of Vienna, to obtain the sanction of all the great European powers to the title he had assumed, and to the territory that had been acquired. The kingdom of Wurtemburg was thus fixed in the condition described in the following pages.

Boundaries and Extent.

The whole is nearly inclosed between Baden and Bavaria, the former bounding it on the western and northern sides, and the latter on the eastern and southern; except that on one part of its southern frontier, the Lake of Constance separates it from Switzerland. It is of an irregular form, extending from 47° 35′ to 49° 35′ north latitude. On a very small portion of its northern boundary, it comes in contact with the grand duchy of Hesse Darmstadt. Its whole extent is 7573 square miles, or 4,846,720 English statute acres.

Divisions and Population.

The ancient divisions of the duchy of Wurtemburg were various, according to their position and feudal claims; and the additional territories, that had been recently acquired, were in very irregular and unequal allotments. Of late, a new division has taken place into circles, which are again subdivided in *Oberamts* or Baillewicks; besides these circles, the capital, the city of Stuttgart, forms by itself a separate division, though its inhabitants are included in the population returns of the Neckar circle.

The circles, their extent and population, are,

	Extent in Statute Acres.	Population.
Circle of the Neckar, ...	904,320	384,599
Circle of the Jaxt, ...	1,318,400	318,999
Circle of the Black Forest, ...	1,204,480	360,951
Circle of the Danube, ...	1,468,160	360,849
	4,895,360	1,425,794

This population is found in 130 cities (having or formerly having had walls), 128 market towns, 1115 parishes, 558 hamlets, 2591 farms, and 269 castles or seats of the nobility. The increase of population, calculated by the excess of births over deaths, has been about 10,000 on an average of several years.

Dialect.

The inhabitants are partly of Swabian, and partly of Franconian origin, and retain the peculiar pronunciation of the races from which they are descended. With these are also some settlements of the Waldenses. The Swabians make use of many words very different from the other German people, and adopt many variations in the idioms not known elsewhere. These may be observed to alter at every ten or twelve miles in travelling through the country.

Religion.

The prevailing religion in Old Wurtemburg was the Lutheran, for which it suffered most severely during the Thirty Years' War. No toleration was granted to any other sect except to the Waldenses, and they were confined within prescribed limits, and even in those spots were under some strict regulations, and excluded from the rights of citizenship. Since 1806, the three religious parties have enjoyed the free exercise of their modes of worship, and a participation in all civic rights, with eligibility to all public offices. The Lutherans in the whole kingdom are 950,000, the Catholics about 430,000. There are many sectaries, such as Separatists, Baptists, Hernhutters, and others, who are neither favoured nor persecuted by the government. Through the whole of Protestant Wurtemburg, there are a great number of persons distinguished by the appellation of Pietists, who hold their private meetings for devotion, but do not in other respects separate from their churches. The Lutheran church is under the direction of six superintendents, whose dioceses are divided into fifty deaconries, and supplied with 818

Wurtemburg.

pastors. The Catholics are governed by a Vicar General, who is assisted by a council consisting of clerical and lay members, the priests under them are about 640. The Lutheran clergy are in general better supported, and taken from a somewhat higher class of people, than in most of the other parts of Protestant Germany. The Jews who have established themselves chiefly in the new provinces of Wurtemburg amount to about 8000 persons.

Education.

Few parts of Germany have exhibited more or better specimens of knowledge and talent than have been produced from the institutions for education in Wurtemburg. The state has, for its population, more means for acquiring learning. The classical endowed schools are fifty-five, from which the theological pupils are transferred to the University of Tubingen, where they are maintained from the funds of the institution. In these establishments the pupils are not confined to mere professional pursuits, but have their attention directed to general knowledge. The University of Tubingen has long been considered one of the best in Germany. There are, besides, the Gymnasium at Stuttgart, and seminaries for the Protestant clergy at Maulbroun, Schoenthal, Ulm, Heilbron, and Ochriengen, and for Catholics at Rothenburg, Rothweil, and Ellwang. Schools for instructing the poorer classes of the people are amply provided in every part of the kingdom, so that the knowledge of reading, writing, and arithmetic, is almost universal. No village is without its school, and scarcely a market town without a classical instructor.

Mountains, Rivers, and Lakes.

The kingdom may be considered as hilly, if not mountainous. On the eastern part is the group of the Swabian Alps, and on the western the Black Forest, a continuation of the Swiss Alps. The highest points of these two groups of elevations are from 2500 to 2800 feet. The eastern are not so lofty as the western ranges of hills, but they are more bleak, raw, and unhealthy. There are no plains, but some extensive and beautiful valleys, highly fruitful, of which that of the Neckar, with its branches, and that of the Danube from Tutlingen to Ulm, are the most celebrated. The various smaller valleys, running up between the hills, and terminating on the banks of the several rivers, present rich and beautiful prospects. The woods are extensive, and contain almost every kind of forest tree; but the absence of hedge-rows is a great drawback to the beauty of the country in most parts of the kingdom. The scenery is much indebted to the rivers and the several tributary streams, which run through all the valleys. The Neckar rises in the southern extremity of Wurtemburg, and, with many windings, leaves the kingdom on its northern frontier, in its course to join the Rhine. It collects the waters of the Kocker, the Jaxt, the Rems, the Ens, the Erms, and the Zaber. The Danube rises in this kingdom, from the mountains of the Black Forest, and leaves it at Ulm, on the frontiers of Bavaria. It is increased by the several streams of the Iller and the Brentz. The Tauber, in the north, is one of those streams which contribute to the waters of the Main. The Schussen and the Argen are two small rivers that empty themselves into the Lake of Constance. That lake borders a small part of the kingdom. The Feder Lake, about three miles in length and breadth, and those of Laufen and Pfaffen, which are smaller, lie within its boundaries.

Agriculture, and its Productions.

The land of Wurtemburg has been recently thus classed: meadows 640,000, arable 1,620,000, woods and forests 1,520,000, and vineyards 61,000 acres; the remainder is either waste or occupied by the lakes, rivers, cities, and towns. In no part of Germany is so much attention directed to agriculture as in this kingdom, and in no part of it are the practices so generally good. The cultivation of green crops is much diffused; turnips, but more especially mangel wurzel, are grown to clear the land from weeds, and to a great extent have superseded the former mode of fallowing. Potatoes are very extensively cultivated, and not only form the chief food of the working classes, but are used for the purpose of making brandy, as well as feeding cattle. The rape and poppy plants are grown for making oil; and that which is expressed from the latter is found to be equal, if not superior, for the use of the table, to the oil of olives. Hemp and flax are raised in abundance, the former chiefly in the middle provinces, and the latter most extensively in the district of the Black Forest. The harvests of corn are tolerably productive of wheat, rye, oats, and, in some of the warmer districts, of maize. The supply of grain is estimated for the whole kingdom at about 23,000,000 bushels, from which, as potatoes are extensively used for food, some is every year sent to supply the wants of the neighbouring states. The woods afford more fuel and building materials than is demanded for domestic consumption, and the surplus, by means of the rivers, is conveyed to the countries lower down the several streams. The vineyards produce abundance of wine, and, though generally not of a good quality, and much of it very bad, its culture is found very beneficial. The best wines usually comprehended in the general class of Neckar wine are those made on the hills near the old castle of Wurtemburg, at Uhlbach, Fehlbach, Upper and Lower Turkheim, Lichtenberg, Rosswag, Maulbroun, and Tauberthal. The most productive vineyards are those on the western borders of the eastern Alps, where a single acre has been known to yield more than 2000 gallons; but it more resembles vinegar than wine. It is generally remarked that the Neckar wines have much deteriorated of late years; which is attributed to negligence in the choice of the most proper plants, and to attention being principally paid to such as yield much, rather than to such as yield the best wine. The wine made in the year 1811, as was the case on the banks of the Rhine, and in most parts of Germany, was of an unusually good quality; and such of it as now remains sells for 300 florins the emir, whilst the wines of later years are not worth more than 130 florins. The whole value of the wines made in the kingdom on an average is L.400,000 Sterling.

Cattle.

The cattle in Wurtemburg have been carefully attended to, and the cows especially are of a very good description; which is attributed to the care in improving the breed, and to their being generally stall-fed, or soiled with green food. The butter is excellent, and in many districts good cheese is made; but the last less extensively than, with due pains, it might

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be. The sheep have been much improved by constant crossings between the old races of the country and those of the Rousillon and Merino breeds, and now the greater part of the flocks are of the fine-woolled kind. The breed of horses was at one time much improved by the introduction of Holstein and English stallions; of late years they have been retrograding, but the government has now been induced to take steps, by introducing studs of the best horses, for improving them again. The number of cattle, in the year 1820, was thus enumerated: horses 80,870, cows 599,490, sheep 488,940, swine 114,200, goats 16,620, asses 1008.

Fisheries.

The fisheries are very productive both in the lakes and the rivers. The Lake of Constance, especially, affords abundance of salmon-trout, perch, carp, and barbel; the other lakes and the rivers yield trout, eels, barbel, pike, and several other kinds of fish; and in the Feder Lake, the shad is found of a very large size.

Minerals.

The only mines that are extensively worked are those of iron, at Neuhausen, Fluorn, Neuenberg, Aalen, and Wasseralfingen. The ore from these mines is prepared both by smelting and the hammer, and supply the manufacturers of Fredicksthal, Christophsthal, Ludwigsthal Harras, and Heidenheim, with minerals for their cutlery and ironmongery. There are saline springs at Hall, Sultz, Offenau, and Weisbach, from whence is annually made about 8000 tons of culinary salt; and a new spring, lately opened at Kochendorf, promises to afford a more copious supply, so as to dispense with the quantity of that commodity now purchased from the kingdom of Bavaria.

Manufactures.

The chief manufactory of Wurtemburg is that of linen. The inhabitants of the eastern Alps and of the Black Forest are employed in this branch of industry. In those districts, almost every female is occupied, in the winter, in spinning; and every peasant is a weaver. Both fine and coarse linen is produced, and also diaper and sail-cloth. In Münsengen, there is a manufactory for damask table linen, which produces most excellent goods. In some parts of the kingdom, the females find employment in making a coarse kind of bone lace. The cloth manufactures are inconsiderable, and seem to be far from flourishing; and much of the wool clipped within the kingdom is either exported in the raw state, or, after being spun, to the neighbouring countries. Cotton spinning and weaving have been introduced at several places, but those establishments are in a languishing state. Leather, glass, paper, snuff, beer, hardware, cutlery, with oil, pitch, tar, and potash, are all made in different parts of the kingdom. The breweries, and especially the distilleries, are numerous. In the large village of Mossingen are no less than 280 stills for making brandy and whisky. This is the country for making wooden clocks, and those works produced in Wurtemburg, or from natives of it, who have transferred their labour to other countries, are to be seen in almost every part of Europe.

Commerce.

The chief commerce of Wurtemburg consists in the exchange of its commodities with the adjoining states. It sells to them 18,000 oxen, 12,000 cows, 75,000 sheep and lambs, and 550,000 lbs. of wool more than it buys. The usual export of corn beyond the import is 80,000 quarters. The other sales consist of linens, leather, snuff, pitch, tar, potash, oil, and wood, and wooden toys of various descriptions. The imports are silk, cotton wool, East and West India productions, flax, hemp, hides, and salt. The balance of payments is usually in favour of Wurtemburg.

Constitution.

The government of Wurtemburg is at present an hereditary limited monarchy. The King is the sole sovereign, and acts without control, by his ministers, in every executive department. He appoints to all offices, makes war and peace, commands the forces, distributes rewards, confers dignities and honours, executes justice, and dispenses pardons. Under the ancient Dukes, within the original territories of Wurtemburg, there existed a feudal constitution. The States, consisting of fourteen prelates and seventy-one deputies from the cities, exercised some legislative authority; but on the assumption of the kingly dignity, and the addition of the acquired provinces in 1806, the monarch assumed unlimited power; until the termination of the war, and the end of the Congress of Vienna, when a new constitution was promulgated. Two legislative chambers were instituted. The upper was composed of the mediatised princes, the high nobility, and the prelates of the Protestant and Catholic churches; the lower consisted of the deputies from the cities of Stuttgart, Tubingen, Ludwigsburg, Ellwang, Ulm, Heilbron, and Reutlingen, from the learned institutions, and from the several baillewicks. The privileges of the nobles were thought by themselves to be invaded, and they did not concur in this constitution. Difficulties arose in reducing to practice the project, and how far it may be realized, or how it may ever work, is at present a doubtful matter. In the opinion of some, too much regard has been had to ancient rights and customs, whilst others think that such rights and customs have not been sufficiently respected. The nobility are dissatisfied with the constitution, though it secures to them some exclusive privileges, and exempts them from some descriptions of taxation, and from military conscriptions. The citizens and the peasants have equal rights, and the feudal slavery of the latter, called *Leibeigenshaft*, is universally abolished. All have equal pretensions to public employments, and all the Christian sects enjoy the same rights. The feudal tenures are destroyed, and the estates formerly subject to them are converted into freehold properties.

Administration.

The administration is executed by six ministers, whose departments are thus denominated,—Justice, Foreign Affairs, Domestic Affairs, War, Finance, and Police. Each of these ministers are at the head of the several Boards which regulate their branch of the executive government. The law is founded upon the ancient feudal principles which prevailed in Wurtemburg at the earliest period, but in some instances tempered by the addition or intermixture of the Roman civil law. The administration of justice in smaller matters, not exceeding five pounds, is executed by provincial judges. There are four superior courts for the four circles; and a supreme tribunal of appeal and revision is established at Stuttgart.

The national income, derived partly from the do-

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mains of the king, and from direct and indirect taxation, amounts to about 11,000,000 gulden annually. The taxes of late years have been lessened, and the whole administration of the finances much simplified and improved. The amount of the national debt, in 1817, was 30,000,000 gulden, or about L. 3,000,000 Sterling, at which period a sinking fund was established, calculated to liquidate the whole in forty-five years by the application of the surplus revenue. The whole expenditure, as appears by the accounts of 1817, was somewhat under 10,000,000 gulden. Of this, 1,000,000 was appropriated by the king for his civil list, and 650,000 for the other members of the royal family. The State paper, a species of certificate somewhat resembling our Exchequer bills, is nearly equal to metallic money.

Forces.

The army is recruited by an annual ballot, to which almost all are subject on attaining their twenty-first year; but from which those are exempt who pay a certain sum into the treasury, or who, on being drawn, provide a substitute. The term of service is six years. The army consists of 12,284 infantry, 3614 cavalry, and 2452 artillery, including officers, the staff, artificers, and the invalids. Besides the regular army, there is a corps of *gens d'armes* under the direction of the police.

Chief Cities.

The most considerable cities and their population are the following: Stuttgart, 30,000, including military; Ulm, 11,027; Reutlingen, 8831; Heilbroun, 6885; Tubingen, 65540; Hall, 6250; Esslingen, 5591; Gmünd, 557; Ludwigsburg, 5226; Rothenburg, 5147; Biberach, 4451; Göppengen, 4423; Kirkheim, 4311.

Weights and Measures.

A new system of weights and measures was introduced in 1807, which is generally adopted now through the whole kingdom. It is founded on the old denominations, but adjusted to decimal divisions. The stund or hour is 1300 roods, or 13,000 feet. Two stunden make a mile, equal to the 15th part of a degree of latitude. The rood is 10 feet 100 inches, or 1000 lines. The foot of Wurtemburg is equal to 127 Parisian lines. Square measure is reckoned in Jaucherten (day's work, or man's mowing), which is 1½ morgen, or 384 square roods, each rood being 100 square feet. For measuring corn the scheffel is used. The scheffel is 8 simri, the simri 4 fierlings, the fierling 4 achtel, the achtel 4 ecklein; the simri contains 942 cubic inches. Liquid measure is the eimer, making 16 ini, 160 mass, or 640 schoppen. The mass is 78 cubic inches. The weights are of two kinds, one according to the practice of Nurenburg, the other that of Cologne. The pound of Nurenburg is equal to 32 loths of Cologne.

See *Neueste Kunde von den Königreiche Würtemburg*, von J. D. G. Memminger, 1820; *Erdebeschreibung*, von Gaspari; *Hassel and Cannabich vierter band erster abtheilung*.

(W. W.)

Y O R

YORKSHIRE, an English county of more than double the extent of any other of the divisions of the united kingdom that are so denominated. It is not more distinguished by its extent than by the numerous and extensive sources of national wealth which, with the various branches of commerce and manufactures conducted by its inhabitants, contribute to the general prosperity of the empire.

Extent and Boundaries.

Yorkshire is in its greatest length from north to south about 86, and its extreme breadth from east to west about 95 miles. Its surface is calculated to be 5960 square miles, or 3,814,400 statute acres. According to the returns under the late Property-tax, the average rent of the land, including the tithes, was 16s. 10d. *per* acre. This county is bounded on the east by the German Ocean; on the north by the counties of Durham and Westmoreland; on the west by the latter county and Lancashire; and on the south by Cheshire, Derbyshire, Nottinghamshire, and Lincolnshire. The river Tees on the north, and the Humber on the south, are boundaries marked by the hand of nature, and so, in some degree, are the ranges of hills on the western sides; but these last are indefinite, and, like most other divisions of countries, those of Yorkshire are mostly imaginary lines, whose position is chiefly ascertained by local tradition.

Grand Divisions.

This county is divided into three portions called Ridings, denominated from their position East, North, and West. The southern part of the county is comprehended within the limits of the East Riding. Each of these Ridings is again divided into *wapentakes* (a name, in the northern equivalent to that of *hundred* in the southern counties), and into a city and several towns, with their contiguous liberties or dependencies, as will be noticed in the account of the separate Ridings.

Members of the Legislature.

In elections for the county the freeholders of the Ridings vote indiscriminately. Hitherto they have returned two members only, but from this time, in consequence of the disfranchisement of the borough of Grampound in Cornwall, and the transfer of the choice of the two members that were returned by it to Yorkshire, the county will return four members to the House of Commons. These, with two each from the city of York, and the boroughs of Aldborough, Beverley, Boroughbridge, Hedon, Hull, Knaresborough, Malton, Northallerton, Pontefract, Richmond, Ripon, Scarborough, and Thirsk, make thirty-two members from Yorkshire. The titles of Peers derived from this county are—Dukes, York, Richmond, and Leeds; Earls, Doncaster (Duke of Buccleuch in Scotland), Scarborough, Pomfret, Beverley, Craven, Mulgrave, and Harewood; and Barons, Hawke, Bolton, Ribblesdale, and Prudhoe.

Population.

The whole population of Yorkshire, according to the census of 1821, consisted of 1,173,187 persons, of whom 580,456 were males, and 592,731 females.

Yorkshire.

The number of *families* were 240,696; of whom 63,830 were chiefly employed in agriculture, 137,011 in trade, manufactures, or handicraft, and 39,818 were not comprised in either of the preceding classes. The West Riding exceeds in population both the others together. Between the years 1811 and 1821, the increase in the population in the East Riding was 14 *per cent.*, in the North Riding 20 *per cent.*, and in the West Riding 23 *per cent.*

Rivers and Canals.

The wealth and fertility of Yorkshire is much promoted by the rivers that in various directions pass through it; and by the several navigable canals, which either unite the different branches of those rivers, or draw from them a supply of water for their immediate use. The Tees forms a boundary to Yorkshire on the side of Durham; but a very small portion of its waters is collected from the former county. In the West Riding, the rivers Ribble and Wenning run to the Irish Sea; they are inconsiderable streams till they enter Lancashire. All the others that have their sources in Yorkshire empty themselves into the German Ocean, in a united river, then denominated the Ouse, through the great estuary, the Humber. The Ouse is composed of the two small rivers, the Swale and the Ure, which unite below Boroughbridge, and soon after receiving the waters of the Nidd, passes by the city of York, to which place it is navigable. It soon after is increased by the reception of the Wharfe on its right bank, and of the Derwent on its left. It then receives the river Aine, whose waters near Snaith have been increased by those of the Calder, and its numerous tributary rivulets; and soon after, on the same bank, the river Don, when its breadth is nearly equal to that of the Thames. The most important canal is the Leeds and Liverpool, which connects together, by internal navigation, the two important ports of Hull and Liverpool; and affords to the manufacturers facilities of exporting their productions from either of those places, as may be most suitable for the various markets to which they are destined. There are several shorter canals which connect the towns with the navigable rivers, or convey from the coal mines their important produce.

North Riding.

The North Riding of Yorkshire is divided into ten wapentakes, two liberties, and the towns of Richmond, Scarborough, and Whitby. The population, in 1821, amounted to 183,381; of whom 90,153 were males, and 93,228 females: the whole number of *families* were 38,731: of whom 16,737 were chiefly employed in agriculture, 11,570 in trade or manufactures, and 10,424 were included in neither of those classes. The largest places, and their population, are the following: Whitby, 12,331; Scarborough, 8533; Northallerton, 4431; Malton, 4005; Pickering, 3555; Richmond, 3546, and Thirsk, 2533. The extent of the Riding has been estimated by Mr Tuke to be 2048 square miles, or 1,311,187 acres, of which 442,565 are uncultivated; the remainder comprises the inclosed lands, open fields, woods, and roads. It is believed, that of the part returned as uncultivated, more than one half might be converted into arable or pasture land.

Face of the Country.

The land on the sea shore is generally lofty, and the cliffs precipitous, varying in height from one hundred and fifty to nine hundred feet. Within this narrow sea boundary is a tract called the Eastern Moorlands, about thirty miles from east to west, and fifteen from north to south. It is apparently a barren country, penetrated with some beautiful and fertile vallies, which are, indeed, narrow, but the hills that rise on both sides of them are cultivated nearly to the top. Rosebury-Topping, a mountain, whose summit is 1480 feet above the level of the sea, overlooks the beautiful vale of Cleveland, and the other parts of the western division of this riding, especially the rich and picturesque districts in the vicinity of Boroughbridge and Richmond. The western moorlands are superior in fertility to the eastern. Some of the dales in this district are celebrated for their beauty and fertility, particularly Wensley Dale, Swale Dale, and some of the smaller sheltered spots.

Agriculture.

The cultivation varies so much, that it is difficult to give even an outline of the different practices. The greater portion of the land is in pasture. In Cleveland and Rye Dale the best wheats are grown; the average produce is somewhat more than twenty-three bushels to an acre. Barley is not much grown, nor rye, except on poor and sandy soils. Oats are extensively cultivated, and great crops are produced in Rye Dale, and some other of the vales; they are chiefly consumed in the manufacturing districts, where they form the food of the greater part of the labourers. In many parts of this riding, a mixture of wheat and rye is sown; this corn is commonly known by the name of meslin, and is made into flour, from which the bread of almost the whole district is composed. The breeding and fattening cattle, and the operations of the dairy, are of more importance to this riding than the growth of corn. The cows are generally of the short horned kind, and they are of small size, but clean made, and fine in the bone. The average weight of the oxen, when fat, is about forty stone. The sheep are still mostly of the old large coarse-boned race, but improvements are proceeding by the gradual mixture of the Dishley and Northumberland breeds. The fine wool clipped in this district is mostly consumed in the domestic manufactures of hosiery, in the knitting of which the females are very generally occupied.

The whole of Yorkshire has been long celebrated for its attention to the breeds of horses, but the chief seat for rearing them is in the North Riding. The horses of Cleveland, being clean made, strong, and active, are well calculated for draft; those of the vale of York, by the introduction of the racing blood, are fitter for the saddle. The vales of the eastern moorlands rear many horses of a smaller but useful breed.

Minerals.

The mineral productions of this division of Yorkshire are not of great account. To the west of Richmond some lead mines are advantageously worked. Iron and copper have been formerly raised; the former metal is still produced near Whitby and Scarborough, but the mines of the latter are abandoned. Coal is found in various parts of the riding, but the quantity is small and the quality bad; and hence the chief supply of fuel is obtained from Durham. The most valuable mineral production is alum,

which is collected and prepared in large quantities at different works on the northern shore of the riding.

Commerce.

The manufacturing industry of the district is productive of some very good linens, of rather a coarse quality, of some knit hosiery, and of gloves, made in and around York. The building of ships is an extensive branch of industry, and is carried on upon a large scale at Whitby, and in a smaller degree at other places. On the same part of the coast, the herring fishery gives employment to some thousands of the inhabitants. The town of Scarborough is much frequented in the summer months for the sake of sea-bathing, as well as for some mineral springs which have been discovered in the neighbourhood. Redcar, a small town in the north-east corner of the county, has lately become a place for sea-bathing, and has considerably increased in consequence of it.

Antiquities.

The most striking remains of antiquity in the riding are Scarborough Castle, and those of the abbeys of Rievaulx, Byland, and Whitby.

Gentlemen's Seats.

Among a vast number of seats of noblemen and gentlemen, some of the most conspicuous and celebrated are—Bishopsthorpe, Archbishop of York; Castle Howard, Lord Carlisle; Duncombe Park, C. S. Duncombe, Esq.; Hornby Castle, Duke of Leeds; Kirkleatham Hall, Sir Charles Turner, Bart.; Marske Hall, Honourable L. Dundas; Mulgrave Castle, Earl Mulgrave; Newby Park, Lord Grantham; Brompton, Sir George Cayley, Bart.; Rokeby, J. B. S. Morritt, Esq.; Gersham, Earl of Darlington; and Aske, Lord Dundas.

East Riding.

The East Riding of Yorkshire is divided into six wapentakes, city of York, Liberty of York, and a district called the Ainsty of York, the borough of Beverley, and the town and county of Kingston-upon-Hull. The population in 1821 amounted to 190,449 persons, of whom 92,761 were males, and 97,688 females. The whole number of *families* was 40,499; of whom 15,480 were chiefly employed in agriculture, 16,637 in trade, manufactures, or handicraft, and 8382 not comprised in either of the preceding classes. The largest places, and their population, was as follows: York city, 20,787; Kingston-upon-Hull, the borough, 28,591, the country part, 2834, and the adjacent parish of Sulcoates, 10,449; making together 41,874. Beverley has, in the town and liberties, 7503 inhabitants, and Howden 4443; none of the other places contain so many as 3000 persons.

Face of the Country.

This division of Yorkshire is not marked with any strong or peculiarly striking features, though, in some few parts, the scenery is good, and, including the sea views, the prospects near the coast rather pleasing. The whole extent of this riding is estimated to be about 920,000 acres, being the smallest of the three. The riding may be divided into three parts, as far as regards its productive powers. The first is a tract of level land, extending from the river Humber to nearly the northern boundary of the district. This is in part a rich soil, and, including Holderness, contains some of the best feeding land in this island. The next division is the Wolds, running from north to south, parallel to the former. They are a range of chalky hills, elevated above the level country about 600 feet. The soil is rather a light and chalky loam, in some places mixed with gravel, in others with clay. The extent is from 300,000 to 400,000 acres. Thirty years ago, a very small portion of these wolds was cultivated; but of late years much of it has been inclosed and converted into corn land. The want of good roads is still felt in this part of the country, though the materials for making such roads are abundant and near at hand. The third natural division of the East Riding extends from the western foot of the wolds to the boundaries of the North and West Ridings. This tract, commonly called the Levels, is every where flat and unpicturesque. The soil is various, but, in general, of a clayey nature; from Gilberdyke to Howden it is very heavy, and though the country is well covered with villages and hamlets, it is extremely dirty, disagreeable, and difficult to travel over.

Soil and Productions.

Agriculture.

No part of England shows more proofs of recent agricultural improvements than this riding of Yorkshire; the wolds have been, by paring and burning, changed from sheep pasture into corn-bearing land. In the low lands, also, great improvements have been made; extensive tracts, formerly flooded a great part of the year, and scarcely producing any thing but rushes, have been drained, and are covered with such crops of grain, that the value of the land has been increased in a most extraordinary degree. The wolds, in their former state, were very well adapted for breeding horses; but in their present improved state, are more profitable as affording pasture for sheep, and as growing corn. The warrens for rabbits were formerly very numerous and extensive, but are now, for the most part, more productive by being covered with herbage of a better quality. The farms, especially on the wolds, and in the southern parts of Holderness, are generally large, renting from L.200 to L.2000 *per annum*. The climate of the East Riding varies considerably. Near the coast, the air is cold, and frequently charged with dense fogs. On the wolds, the cold is more severe, and the snow lies longer; but to the westward of the hills, the air is warm, moist, and tends to produce agues. There are no mines in this riding, nor any manufactures, except it be the spinning of flax, which is performed by the ancient method, and is carried on by all the females in the farming houses at their leisure time. The foreign and internal commerce of the riding is wholly carried on through the port of Hull, a place which has thriven during the last forty years as much as any portion of the kingdom. During that period, its population has been more than doubled, and its mercantile shipping and other property been increased far beyond that ratio.

Commerce.

Extensive docks have been constructed for the reception of vessels, and for affording facilities in the landing and storing their cargoes. Around these docks a new town has arisen, on what was formerly a swamp, which surpasses the ancient part in cheerfulness and beauty. The foreign trade of Hull consists in the importation from Russia, Sweden, and Denmark, of naval stores, and the other productions of those countries, and in the exportation to them of the manufactured goods produced in the counties of York, Lancaster, Derby, Cheshire, and Nottingham,

Yorkshire. with which the town is connected by means of canal and river navigation. The same description of trade is carried on betwixt Hull and the ports of Holland and Germany, as exists betwixt it and the towns on the Baltic Sea. Although these are the most ancient and the most natural sources of the commerce of Hull, yet it is by no means confined to them. Considerable trade is carried on with the United States of America, with the West Indies, with the ports of the Mediterranean, with Spain and Portugal, and recently with South America. The building and equipping of ships is a source of great employment, and some ships as large as of 74 guns have been built here during the war. Many vessels belonging to Hull ship-owners are to be hired for freight, and may be found in almost every part of the globe. The whale-fishery has, from the first years of the discovery of Greenland, been pursued by the inhabitants of Hull; but with pre-eminent success ever since the year 1766, when an individual merchant of that town gave an impulse to that branch of industry by which its prosperity has been much promoted. The internal trade through Hull is of great extent; the calculation of the amount of the goods passed through it to and from the interior, by means of the rivers and canals, makes it upwards of L.15,000,000 Sterling annually.

The fishing for herrings is carried on, though to a small extent, in some of the coast towns of this riding.

Interesting Objects. The most interesting objects in this division of Yorkshire are, the natural caves at Flamborough Head; York Minster; Howden Church; Kirkham Priory; Bridlington Priory, and Trinity Church in Hull.

The most distinguished seats of noblemen and gentlemen are, Wressle Castle, Lord Egremont; Birdsal, Lord Middleton; Boynton, Sir William Strickland; Cave Castle, H. B. Barnard, Esq.; Burton Constable, Francis Constable, Esq.; Ferriby, Sir H. Etherington; Hotham, R. C. Burton, Esq.; Ragwell, D. Sykes, Esq.; Sledmere, Sir M. M. Sykes, Bart.; Woodhouse, Robert Denison, Esq.; Melburn, Sir Henry Vavasour, Bart., and Scampson, Sir William St Quintin, Bart.

West Riding. The West Riding of Yorkshire is by far the most important, whether as regards its extent, population, activity, or wealth. It is divided into nine wapentakes, and into a small district denominated the Ainsty of York. The population in 1821 amounted to 799,357 persons; of whom 397,542 were males, and 401,815 females. The whole number of *families* was 161,466; of whom 31,613 were chiefly employed in agriculture, 108,841 in trade, manufactures, or handicraft, and 21,012 were not comprised in either of the preceding classes. The great increase of inhabitants in the West Riding of Yorkshire has chiefly arisen from the various manufactures which have been established there in consequence of the cheapness of fuel, and of the numerous rivers, whose streams are calculated to turn powerful machinery. It has hence followed, that the greater numbers of the people are in townships and parishes rather than in what can properly be called towns. Many of these parishes are continued streets of buildings, but more of them are scattered clumps of houses, each known by some designating name. The population of the towns and parishes of more than 5000 souls are as follows:—Halifax town, 12,628; the whole parish which, in 1811, contained 73,415 persons, had increased, in 1821, to 92,850; Leeds town and liberty, 83,796; Sheffield town, 42,157; but the parish, 52,105; Bradford town, 13,064; but the parish, 62,954, though, in 1811, only 36,358; Huddersfield parish, 24,220; Almondbury, 23,979; Wakefield, 22,307; Kirk-Heaton, 21,870; Birstall, 21,217; Dewesbury, 16,261; Calverley, 14,134; Kirk-Burton, 13,695; Ripon, 13,096; Ecclesfield, 12,496; Rotherham, 9633; Otley, 9358; Keighley, 9223; Doncaster, 9117; Pontefract, 8824; Guisley, 8409; Barnsley, 8284; Bingley, 7375; Rothwell, 6253; Thornhill, 5458; Skipton, 5479; Knaresborough, 5283, and Mirfield, 5041.

Face of the Country. The West Riding is about 95 miles in length from east to west, and about 48 in its greatest breadth from north to south. The square extent is estimated at 2500 miles, or 1,568,000 statute acres. The face of the country furnishes scenes strikingly contrasted. The eastern portion stretched along the banks of the Ouse is generally a flat, moist, and marshy district, in some parts fruitful, but in all uninteresting to the tourist. The middle part, as far as Sheffield, Bradford, and Otley, is an undulating country, finely varied, and rising gradually till it reaches the most western portion, which is very rugged and mountainous. Beyond Sheffield black moors are the only objects, till Blackstone Ledge is reached, on the confines of Lancashire. The western part of Craven presents heaps of rocks and mountains in the most picturesque forms and situations. Among these Pennygant, Wharnside, and Ingleborough, the most conspicuous, may be considered some of the loftiest mountains in England. According to the *Trigonometrical Survey* of Colonel Mudge, the height of Wharnside is 2263 feet, of Pennygant, 2270, and of Ingleborough, 2361. Amidst the hilly and mountainous tracts of this riding are many romantic and some sequestered vallies, presenting the most beautiful scenery. The most extensive of these are Netherdale, watered by the Nid; Wharfdale, and the vale of Aire; but many of the smaller vales vie with them in picturesque beauty; and, being generally inclosed, well wooded, and thickly studded with villages and houses, present, from the surrounding eminences, most enchanting prospects; combining often in the same view the most sublime and the most lively of rural scenery. The roads from Knaresborough or Ripon to Pateley Bridge; from Tadcaster to Otley and Skipton; from Leeds, by Bradford and Keighley, to Skipton; from Bradford to Halifax, and from Halifax, by Dewesbury, to Wakefield, unfold some of the finest scenery that can be seen in this island. The climate of this riding is very much varied; in the eastern part near the Ouse it is warm and moist; in the middle district the air is sharp, clear, and generally considered healthy; in the western parts the climate is cold, tempestuous, and rainy. The mountains of Craven and the moors near Blackstone Ledge are the most foggy, rainy, and stormy dis-

Yorkshire.

tricts in England, though the climate is considered to be salubrious to those of sound constitutions, and the inhabitants have a robust and healthy appearance.

Agriculture and its Productions.

A very great portion of the land of this riding is possessed by small proprietors, although some few noblemen have extensive tracts of land. Most of the occupancies are rather small; none are large; the greater part are less than fifty acres. A great part is kept exclusively in grass, and used for the dairy, or for fattening cattle. On the arable lands a greater quantity of wheat is raised than of any other grain. It is mostly of the red kind, and is sown after fallow or turnips, but sometimes on a clover ley. Rye is not cultivated to any great extent. Barley is raised in much less quantities than wheat. Oats are cultivated to a great extent, but little attention is paid to procuring the best seed, though oatmeal forms the chief part of the food of the inhabitants, especially in the more western parts of the riding. Pease are not much raised, nor beans, except on the moorish soils near the Ouse. The turnip husbandry is not so extensively practised as good farming requires, and where it is pursued, it is generally executed in a slovenly and imperfect manner. Great crops of potatoes are raised in the part of the riding below the junction of the river Aire with the Ouse. In the same part of the country much flax is grown, the preparation of the land for which employs the labour of many hands, as does the dressing and preparing the article for market. Rape for making oil, and woad for the dyers, are both cultivated in this riding, but not to any great extent. The waste lands in the West Riding were estimated about twenty-five years ago at 400,000 acres, of which 250,000 were considered capable of profitable improvement, and the rest fit for no other purpose but that of planting. Since that period much marsh land has been drained, many commons inclosed, and some bleak hills planted with Scotch firs and larches. Vast improvement has been made on some large tracts of land by the operation locally called *warping*. It is performed by permitting the river, at the highest of the tide, to overflow the land. The rich mud with which the turbid rivers abound is deposited on the surface, and each return of tide increases the earth thus deposited, so that a depth of alluvial soil of fourteen inches has been raised by this means on a field which previously was scarcely of any value. The lands thus improved are so enriched, that they will yield abundant crops for several successive years without any manure. The horned cattle, sheep, and horses of the West Riding have no distinguishing characteristics, but vary in kind as in the other two ridings. There is not here the same care exercised in improving the breed of horses as in the other two divisions of Yorkshire.

Minerals.

In this division of Yorkshire the mines produce great quantities of coal, ironstone, and lead, and vast quarries of limestone. The coal and limestone, indeed, appear to be almost inexhaustible. The limestone district commences on the tract between Doncaster and Tadcaster, and extends to the western limits of the county. The coal mines are most numerous between Leeds and Wakefield, and in the neighbourhood of Bradford, Barnsley, and Sheffield, although there are many in other parts of the riding. Iron is found in the greatest quantities near Bradford, and often in the same mine with coal. The best strata of coals are those found under the seams of iron, at a depth of from 220 to 240 feet below the surface. The chief mines of lead are at Grassington, a manor belonging to the Duke of Devonshire, about ten miles to the westward of Pateley Bridge.

Manufactures.

The great branches of industry which have so rapidly peopled, and so vastly enriched the West Riding of Yorkshire, are the several manufactures that have been established in every part of it. Scarcely a hamlet or even a house is to be found wherein some part of one or other of the occupations of manufacture, or of those subservient to it, are not seen in different stages of progress. The iron and other hardware goods are produced at Sheffield, Rotherham, and all the villages in the vicinity of those towns. A little to the northward the large towns of Leeds, Halifax, Bradford, Huddersfield, Wakefield, and the overflowing villages of Almondbury, Kirk-Heaton, Birstall, Dewesbury, with many other places, are devoted to the production of woollen, worsted, cotton, and some linen goods. To name every description of these goods which are perfected in this district, would be to enumerate the whole catalogue of British manufacture. The manufactures have enriched, to an almost incredible extent, the soil in the vicinity of the towns in which they have been expanding, and increased the population in a corresponding ratio. Whilst in the period from 1811 to 1821 the population in the East Riding of Yorkshire, which is an agricultural country, has increased 14 *per cent.*; in the West Riding, as has been before noticed, in the same period it has increased 23 *per cent.*

Antiquities.

The most remarkable remains of antiquity in this riding are Selby Abbey, Knaresborough Castle, Fountain's Abbey, Skipton Castle, Bolton Priory, Kirkstall Abbey, Conisbrough Castle, and Roche Abbey.

Gentlemen's Seats.

In proportion to the great extent of the West Riding of Yorkshire, it contains more seats of noblemen and gentlemen of distinguished beauty than any other part of Great Britain. Our limits do not allow of our even noticing one tenth part of them, but the most remarkable are the following: Wentworth House, Lord Fitzwilliam; Harewood, Lord Harewood; Farnley Hall, Walter Fawkes, Esq.; Ripley Castle, Sir William Ingilby; Thundercliffe Grange, Lord Effingham; Metheley Park, Lord Mexborough; Gisborne Park, Lord Ribblesdale; Brodsworth, Lord Rendlesham; Sandbeck, Earl Scarborough; Studley Royal, Miss Lawrence; Ribstone Hall, Sir Henry Goodricke, Bart.; Copgrove, Henry Duncombe, Esq.; Bramham Park, James Lane Fox, Esq.; Ledstone Lodge, M. Angelo Taylor, Esq.; Wentworth Castle, Henry Vernon, Esq.; Cusworth Hall, William Wrightson, Esq.; and Campsall, Bacon Frank, Esq.

See Tuke's *Agriculture of the North Riding;* Rennie, Brown, and Sheriff's *West Riding;* and Latham's *East Riding: Yorkshire Gazetteer* by Hargrove; *Topographical Dictionary of Yorkshire* by Langdale; *Parliamentary Population Returns;* Bigland's *Beauties of England and Wales.* (W. W.)

Z A I

ZAIRE, a very considerable river of Southern Africa, sometimes called *Congo*, from the district of that name in the possession of the Portuguese, through which it flows and discharges a large volume of water into the Southern Atlantic, in latitude 5° 50′ south, longitude 12° 40′ east.

It may be noticed, however, that the word *Zaire*, like those of *Nile* or *Ganges*, is a general appellation for any great river, and that the proper name of the one in question is *Moienzie Enzaddi*, the *Great River*, or the river which absorbs all other rivers.

There are some peculiarities in the lower part of the Zaire which had long attracted the attention of English traders; but owing to the combined effects of Portuguese jealousy, ignorance, and total indifference to all research which had for its object the extension of human knowledge, the baneful influence of which is felt in all their foreign establishments, nothing whatever was known of its source, or even of the general direction of its course through the continent, beyond some 80 or 90 miles from its mouth.

The accounts that had been given by early writers of the violence and impetuosity of its current, which was said to carry its waters perfectly fresh for twenty leagues into the sea, and the unfathomable depth of its channel, drew from Purchas, the quaint compiler of the *Pilgrimage*, the following amusing description, in his usual and best style: "The Zaire is of such force, that no ship can get in against the current but neer to the shore; yea, it prevails against the ocean's saltness threescore, and as some say, fourscore miles within the sea, before his proud waves yield their full homage, and receive that salt temper in token of subjection. Such is the haughty spirit of that stream, overrunning the low countries as it passeth, and swollen with conceit of daily conquests and daily supplies, which in armies of showers are, by the clouds, sent to his succour, runnes now in a furious rage, thinking even to swallow the ocean, which before he never saw, with his mouth wide gaping eight and twentee miles, as Lopez affirmeth, in the opening; but meeting with a more giant-like enemie, which lies lurking under the cliffes to receive his assault, is presentlie swallowed in that wider wombe, yet so, as always being conquered, he never gives over, but in an eternall quarrell, with deepe and indented frownes in his angry face, foaming with disdaine, and filling the aire with noise (with freshe help), supplies those forces which the salt sea hath consumed."

The first correct account of its real magnitude and velocity was given by Mr Maxwell, who, in the capacity of an African trader, resided in the country, and surveyed the lower part of it. The tendency of its channel to a northerly direction, the times of its flooding, and the great body of water which it discharged, induced him to think that it might be a prolongation of the Niger,—an idea which the late Mungo Park caught up and warmly adopted in the progress of his last unfortunate attempt to solve the problem of the course and termination of this mysterious river. Park had learned from a native of Kashna, that the Joliba, near that city, took a direction towards the right hand; and if so, it was not unnatural to conclude, that, if one great river ran to the southward without any known termination, and another great river came from the northward, whose source was equally unknown, there was at least a probability that they might be one and the same river. And as there was not the shadow of any information which tended to refute this supposition, and as the hypothesis involved no physical impossibility, while many plausible arguments were offered in favour of it, the Board of Admiralty, with that readiness which it has always shown, since the conclusion of the war, to afford opportunities for correcting and extending our geographical knowledge, sent out a small vessel, together with a transport, under the command of Captain Tuckey, with the view of tracing the course of the Zaire as far as it might be practicable. On the arrival of the vessels, destined for the examination, opposite to the mouth of the Zaire, they experienced no little difficulty in getting within it against the stream of a rapid current; and they found that the accounts given of the turbid water, the floating islands covered with trees and bushes, which had been torn from its banks and washed down into the sea, had not been greatly exaggerated. The rapidity of the current between the two headlands which form its mouth, being generally at the rate of five or six miles an hour, renders it impossible to obtain soundings. In the chart of Mr Maxwell, the mid channel is marked at 100 fathoms; but Mr Fitzmaurice, the master of the Congo, employed on the expedition, could get no bottom with 160 fathoms, at the distance of 25 miles above the mouth: where the river is contracted to something less than three miles, the depth was still found to be about 100 fathoms. At 50 miles, the stream is broken and interrupted by rocks and islets, and divided into a number of branches; but at 90 miles, it was again found to be one channel of a mile to a mile and a half in width, and of various depths, from 50 to 30 fathoms; and this depth and width it maintains as high up as Point *Sondie*, 140 miles from its mouth. Here it suddenly contracts its stream to the width only of 400 or 500 yards, and continues so to a place called Inga, about 40 miles above Sondie; being bristled all the way with rocks, so as to be unnavigable except by boats, and that not without difficulty and considerable danger.

The banks by which the river is thus contracted are composed of slate, and every where precipitous. In numerous places, ledges of slate cross the river from bank to bank, forming rapids or cataracts, known to the natives by the name of Yellala. That which first occurs is the highest and the most formidable of these barriers; being a sloping bed of mica slate, over which the river falls from a height of about 30 feet perpendicular, in a slope of 300 yards. In the low state of the river when Captain Tuckey visited it, this Yellala scarcely deserved the name of cataract; but it was said by the natives to make a

Zaire.

tremendous noise when swelled by the rains. Compared with Niagara (says Captain Tuckey), it was a mere brook bubbling over its stony bed. One thing, however, surprised the party; it was, that the quantity of water which fell over the ledge was but a small portion of the volume below; and the only explanation which offered itself to them was, that a subterranean communication existed between the upper and lower part of the cataract beneath the sloping bed of slate.

At Inga, where the narrows terminate, the river once more became navigable, and stretched out into a magnificent sheet of water, expanding to the width of two, three, and even more than four miles, flowing with a gentle current of two to three miles an hour. Thus it continued to the distance of about 100 miles beyond Inga, or 280 miles from Cape Padron. Here, however, the whole party were compelled to stop, partly from sickness, but chiefly because the natives refused to accompany them farther. At this place it is said the river had "a most majestic appearance; that the scenery was beautiful, and not inferior to any on the banks of the Thames; that the natives of this part all agreed in stating, that they knew of no impediment to an uninterrupted navigation of the river upwards; that at no great distance it divided into two branches; and that there was only one obstruction in the north-eastern branch, occasioned by a single ledge of rocks, forming a kind of rapid, over which, however, canoes were able to pass."

All this, under more prosperous circumstances, would have held out the strongest inducement to proceed; but it was found impossible, and, therefore, the question of the identity of the Niger and the Zaire was left pretty much in the same state of uncertainty as it was before the expedition. Little doubt, however, seemed to remain on Captain Tuckey's mind, that the north-eastern branch had its source in Northern Africa; for he observes, that, "Combining his observations with the information which he had been able to collect from the natives, vague and trifling as it was, he could not help thinking that the Zaire would be found to issue from some large lake, or chain of lakes, considerably to the northward of the line." He was the more inclined to this opinion, from the low state of the river, even so late as August; and he adds, "Should it begin to swell in the early part of September, an event I am taught to expect, I shall conclude that my hypothesis is correct." It did begin to swell at the period anticipated, and he notes down in his journal, in two words, "Hypothesis confirmed." The idea of its flowing out of a lake seems to have arisen from its "extraordinary *quiet* rise," which was only from three to six inches in twenty-four hours; whereas, had the swelling of the river been occasioned by rains falling to the southward of the line, and by the pouring into its channel of mountain torrents, the rise must have been sudden and the stream impetuous; but coming on, as it did, in a quiet and gradual manner, it was concluded that it could proceed only from the gradual overflowing of a lake.

Thus, the course of the Niger still remained as a matter of speculation, and the swamps of Wangara (a name no longer known in Africa), the Bahr el Abiad, the Zaire, and the Rio Formosa and other sluggish waters which are discharged into the Bight of Benin and Biafra, continued each to have their advocates. The two latter hypotheses must, however, now be for ever abandoned. The accounts which have recently been received from the African travellers, Oudney, Clapperton, and Denham, set the question completely at rest, as far as the Zaire and the Rio Formosa are concerned. We may now safely say, that these waters are completely divided from those of the Niger by a barrier of lofty primitive mountains, from the southern side of which they undoubtedly receive their supply of waters, as the Niger and the lake of Bornou receive theirs from the northern side.

Having disposed of the Atlantic rivers, it remains only to be shown what progress has been made in determining the course and termination of the Niger beyond Timbuctoo; indeed, we may say, beyond Houssa, for to that extent it has unquestionably been traced in its easterly course, by every modern authority, written and verbal. By Houssa must be understood, a considerable tract of country to the northward of the Niger, interjacent between Timbuctoo and Bornou; of which Kashna or Kassina is the capital. Considerable light has been thrown on this part of Northern Africa by a native of the above mentioned city, who has recently left Cape Coast Castle with Belzoni on his journey home. This man had served many years in the British navy, under the name of William Pasco, but his real name is Abou Beker. By his own account, he travelled with a party of merchants from Kashna, or, as he calls it, Birnie-Kashna, to the Bight of Benin. To the southward of this city, and at the distance of four long days' journey, or about 100 miles from it, they crossed the *Quarra-luan-dadi*, or river of fresh water, which he describes to be as wide as the Gambia at St Mary's, running to the eastward. Five days further, still travelling south, they crossed a deeper and broader stream, also running east, called the *Gulbi*, which passes through the countries named *Guari* and *Nooffi*; and he has been told, and believes, that these two rivers unite at *Zugum* near *Kaba*, and proceed towards the rising sun to Birnie-Bornou. Several days after this, they reached a high range of mountains, one part of which had the top white like marble, and in its appearance resembled *Fogo*, one of the Cape de Verd Islands. Having crossed the mountains, and a small river called Echoo running at their feet, they saw the sea; and continuing their route towards the setting sun, having the sea in sight at intervals on the left hand, in ten days he reached Annamaboo on the coast, and entered on board his Majesty's ship the Lille Belt.

Abou Beker is represented as an intelligent man, and the account he gives of his journey is considered by the writer of a late article in the *Quarterly Review*, on the progress made by our African travellers, as worthy of credit. No other river than the two branches he mentions intervened in his route to the southward; and this corresponds

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with the account given by Major Denham of his route in the same direction, but on a more easterly meridian, who met with nothing like a stream in travelling directly south between the river Yaou, in latitude 13° 30′, and a part of the chain of mountains crossed by Abou Beker, in latitude about 10° N.

This Yaou is, in fact, the only stream of water that occurred to our travellers between Mourzouk and the mountains above mentioned, and cannot possibly therefore be any other than the Niger or Joliba; unless we are to suppose this river to have sunk or been evaporated before it reaches thus far to the eastward. Indeed, it appears, from the latest letters received from Dr Oudney, dated in July last (1823), that they had followed up the Yaou 200 miles to the westward, and found it sometimes a stream between deep banks, and at other times swelling out into small lakes. As Noofi, or the lake of Soudan, into which the Niger is known to fall, could not be more than 100 miles from the spot to which the party proceeded westerly, there can scarcely be a doubt that the Yaou and the Niger are identical. Beker states, he has often heard his grandfather say, that Birnie-Bornou was about fifteen days' journey from Birnie-Kashna towards the rising sun, which accords pretty well with the accounts given by Hornemann and others. This traveller (Hornemann) names the river in that part of its course where it enters Bornou the *Zad*; and says (what is now confirmed) that it falls into a large lake, which Burkhardt states to be in Bornou, and that it is a fresh water lake.

It will be seen that under the Article AFRICA it is stated, as a speculation grounded upon the reports of various travellers, that a great lake or inland sea would one day be found in some part of Northern Africa, as a common receptacle of the several rivers, of the course of which so many contradictory statements have been given. It was not pretended to assign the precise situation of this lake, but it was conceived it might be somewhere "in an extensive tract of desert, immediately to the east of the modern position of Houssa;" meaning thereby to the eastward of Kashna. That lake is no longer a matter of speculation but of fact. Dr Oudney and his companions fell in with it at a place called *Lari*, the frontier town of Bornou, in latitude 14° 40′ north, longitude 13½, being very nearly in the same meridian with Mourzouk. Its name is the *Tsaad*, being the same as that given to the river which falls into it about sixty miles farther south, by Hornemann and Burkhardt; but which, as already mentioned, is called by the present travellers the *Yaou*. The western shore of the lake was traversed not less than 220 miles, in a direction almost due south; and at the southern extremity a large river of the name of *Shari*, a full mile in width, was found to flow into the lake in latitude about 11° 30′. It came from the south, and undoubtedly had its rise in the great chain of mountains visited by Major Denham, and crossed by Abou Beker. How far the lake *Tsaad* may extend to the eastward is yet uncertain; but it is to be hoped, that the next accounts from the travellers will settle this interesting point, and determine the question whether, on that side, a river flows out of it in an easterly direction towards the Nile of Egypt, or that it is the great sink of Africa, receiving its waters from all directions. It is said that no mention is made whether the waters of the Tsaad be fresh or salt; the very omission of which we think is decisive of its being fresh; and if so, there is certainly a strong probability of its having an eastern outlet; a circumstance which would afford an equal probability of the identity of the Niger and the Nile, their union being effected through the channel of the Bahr el Abiad: for, in such a climate, and such a soil as those of central Africa, every lake without an outlet must be more or less salt, like the lake Asphaltites, and the numerous salt lakes of Persia. As the country all around, for many hundred (perhaps thousand) miles, is a dead flat, stated to be from 1200 to 1500 feet above the level of the sea, we want only to ascertain the level of the plain of Sennaar, where the Bahr el Abiad joins the Nile, to determine at least the *possibility* of the waters of the Tsaad emptying themselves into the Mediterranean.

We shall here only add, that the Tsaad must be of very considerable extent to the eastward, as a set of ferocious people, of the name of *Buddooma*, inhabiting some of its islands, come on rafts from that quarter, and carry off women, children, and cattle, from the western shores of the lake, beyond the possibility of their ever being recovered; at least, hitherto, the people of Bornou, who have boats sewed together from forty to fifty feet in length, have never ventured far enough to discover their haunts. Beautiful little islands, covered with the Papyrus, are seen floating about the lake in various directions, according to the quarter from which the breeze blows. (K.)

ZEALAND, NEW. See the Article AUSTRALASIA in this *Supplement*.

4

Fluents || Interpolation.

ADDENDA ET CORRIGENDA.

FLUENTS, Vol. IV. No. 5. *For* $\int y\mathrm{d}z$ *read* $\int z\mathrm{d}y$

No. 203. *For* $\frac{x^2\sqrt{y}}{5b}$, *read* $\frac{y^{\frac{5}{2}}}{5b}$

After No. 546. *for* $\int Y\mathrm{d}Z$, *read* $\int Z\mathrm{d}Y$; in the next line *read* . . . (n.5), taking the $\mathrm{d}Y$ of this theorem $= \mathrm{hl}^{n} x \frac{\mathrm{d}x}{x}$, $\mathrm{d}X = \frac{\mathrm{d}x}{x}$, and $Z = yx$, we have $\int Z\mathrm{d}Y = \int y \mathrm{hl}^{n} x.\mathrm{d}x = \mathrm{hl}^{n} x \int yx \frac{\mathrm{d}x}{x} - \ldots$ $= \mathrm{hl}^{n} x \int y\mathrm{d}x - \ldots$; thus, if $y = x^{m}$

After No. 555. *for* $\int Y\mathrm{d}Z \ldots$, *read* $\int Z\mathrm{d}Y = \frac{\mathrm{d}Y}{\mathrm{d}X}\int Z\mathrm{d}X - \ldots$, we may put $\mathrm{d}X = \mathrm{d}x$, and either $y\mathrm{d}x = \mathrm{d}Y$, and $a^{x} = Z$, or $a^{x}\mathrm{d}x = \mathrm{d}Y$, and $y = Z$; and

After No. 569. *for* $\int Y\mathrm{d}Z \ldots$, *read* $\int Z\mathrm{d}Y \ldots \mathrm{d}Y = e^{-xx}x\mathrm{d}x$, $\mathrm{d}X = \mathrm{d}(-xx) = -2x\mathrm{d}x$, and $Z = \frac{1}{x}$, we have, 570. $\int e^{-xx}\mathrm{d}x = -e^{-xx}(x) + e^{-xx}\frac{2}{3}x^3 + \ldots = e^{-xx}\left(x + \frac{2}{3}x^3 + \frac{4}{3.5}x^5 + \ldots\right)$

No. 571. A similar correction is required for $\int \frac{\mathrm{d}y}{\sqrt{\mathrm{hl}\frac{1}{y}}}$, which becomes $= \sqrt{\frac{y}{(\mathrm{hl}\frac{1}{y})}}\left(1 - \frac{1}{2(\mathrm{hl}\frac{1}{y})} + \frac{3}{4(\mathrm{hl}\frac{1}{y})^2} - \frac{3.5}{8(\mathrm{hl}\frac{1}{y})^3} \ldots\right)$ See Méc. Cél. X. p. 253.

No. 572. *read* $\int e^{x^m}\mathrm{d}x = e^{x^m}x - e^{x^m}\frac{m}{m+1}x^{m+1} + \ldots$

Add—Some other similar fluents of logarithmic quantities may be found in the *Journal* of the Royal Institution for October 1823.

Fluents || Interpolation.

INTERPOLATION. Few disquisitions in modern mathematics have greater practical utility than those concerning the extension and interpolation of the terms of numerical progressions. But the modes of solution generally proposed, however ingenious and refined, are often too complex for ordinary purposes. We therefore avail ourselves of this opportunity to point out a procedure of extreme simplicity and most ready application. It will embrace any system of numbers, but seems peculiarly fitted for the computation of logarithms.

Napier first published, in 1614, his canon *Mirificus Logarithmorum*, comprised in a very thin and small *quarto* volume, exhibiting, as far as seven places, the logarithms only of the sines and tangents to every minute of the quadrant; those of the ordinary numbers being left to be deduced from the nearest sines or tangents. In the summer following, Briggs, then Professor of Geometry in Gresham College at London, who was enchanted by that noble discovery, paid a visit to its illustrious author at Merchiston, in the vicinity of Edinburgh. During an agreeable stay of a month, it was concerted between them, to change the natural system of logarithms into another of a more artificial form, but adapted to our denary scale of notation, the labour of the calculation, however, being devolved upon Briggs, as younger and enjoying robust health. Next season, Briggs performed a second journey to Edinburgh, and showed to Napier a table which he had computed of the new logarithms for the first chiliad or thousand of the series of natural numbers. But the great inventor was now fast declining in years, and expired on the 3d of April 1618. Briggs employing most skilfully all the abbreviations which ingenuity could devise, prosecuted his most arduous task with such vigour and active perseverance, as to compute, in the space of seven years, to fourteen places of figures, not only the logarithms of

the sines and tangents of every degree and centesimal minute of the quadrant, but also the logarithms of thirty chiliads of numbers. These tables were printed, in 1624, in a *folio* volume, entitled *Arithmetica Logarithmica.* In his anxiety, however, to bring out this stupendous work, Briggs contented himself with calculating the logarithms from unit to 20,000, and from 90,000 to 100,000, leaving the computation of the seventy intervening chiliads to be afterwards supplied. The very ingenious author annexed a full explanation of his mode of framing the tables, grounded chiefly on the consideration of differences, and he thus traced the first steps of that important theory. But he likewise gave instructions for the readier filling up of the intermediate logarithms, abridging the toil of calculation no doubt, yet detailing a procedure sufficiently irksome and complicated. "To encourage some skilful persons to perform this task, he offered to furnish them with paper he had by him, ready prepared, and divided into columns proper for that purpose, as likewise to inform them at what part to begin, that they might not interfere one with another; and promised, when the whole was finished, to endeavour to procure a new edition of the work so completed." This slender boon seems not to have tempted the mathematicians in England. In Holland, however, Adrian Vlacq, chancing to meet two years afterwards with a copy of the work, and prompted only by his patriotic zeal, had the resolution to revise and compute the whole canon, reducing it to ten places of figures, which he printed in *folio* at Gouda, as early as 1628. The same able calculator, only five years afterwards, published, likewise in folio, at Gouda, a very extensive system of logarithmic sines and tangents, to every ten seconds of the quadrant, having restored the sexagesimal subdivision, which Briggs had partly changed into a centesimal one. These two volumes may be deemed a precious *thesaurus* of logarithms, from which succeeding compilers have drawn very liberally. They form the basis of the *Tables* published by Vega at Leipsic in 1794, which are esteemed the best and completest now extant.

But though the *Tables* of Vlacq, carried only to ten places of figures, are sufficiently accurate for every ordinary purpose, and even for the most delicate calculations in astronomy, yet many persons have often regretted that the original system of Briggs was never completed. The celebrated Legendre has employed that table, imperfect as it is, in some of his most refined numerical investigations. It is well known that Mr Baron Maseres devoted a considerable portion of his time, and of his fortune, to the republication of the works of the early writers on logarithms. In the course of this extensive undertaking, he entertained some thoughts of giving a new edition of the *Arithmetica Logarithmica*, and expressed an earnest wish that the vacant chiliads were filled up. To promote the liberal designs of the Baron, the Author of this Article was induced to bestow some reflection on the subject, and a very simple mode occurred to him, which would have reduced the labour of computing those logarithms to little more than the trouble of mere transcription. But the project of completing the canon was deferred for a time, and afterwards gradually forgotten. The method of interpolation then proposed seems, however, to deserve notice on account of its great simplicity, and its ready application, not only to the immediate object, but to other questions of a similar nature. We shall, therefore, now state the principle, and illustrate its application by a few examples.

The square root of the quantity a^2+1 is evidently expressed by the continued fraction $a+\cfrac{1}{2a+\cfrac{1}{2a+\&c.}}$

If two terms only of the fractional part be taken, the expression will become $\sqrt{a^2+1}=\frac{4a^3+3a}{4a^2+1}$, and consequently $\sqrt{\left(\frac{a^2+1}{a^2}\right)}$ or $\sqrt{\left(\frac{2a^2+2}{2a^2}\right)}=\frac{4a^2+3}{4a^2+1}$, a very near approximation. Put $b=2a^2$, and by substitution $\sqrt{\left(\frac{b+2}{b}\right)}=\frac{2b+3}{2b+1}$; wherefore $\frac{1}{2}\log.\frac{b+2}{b}=\log.\frac{2b+3}{2b+1}$. Hence half the alternate differences of the logarithms of the series b, $b+1$, $b+2$, &c. added to the logarithm of $2b+1$, must give the logarithm of $2b+3$. By this simple process then, any table of logarithms is carried to double its actual extent through all the odd numbers, those of the even ones being found by the mere addition of the logarithm of 2.

To find the limits of approximation, let three terms of the fractional series be taken, and $\sqrt{\left(\frac{a^2+1}{a^2}\right)}=$

$$\frac{8a^4+8a^2+1}{8a^4+4a^2}, \text{ or } \sqrt{\left(\frac{b+2}{b}\right)}=\frac{2b^2+4b+1}{2b^2+2b}=$$
$$\frac{2b+3}{2b+1}\left(\frac{4b^3+10b^2+6b+1}{4b^3+10b^2+6b}\right)=$$
$$\frac{2b+3}{2b+1}\left(1+\frac{1}{(2b+3)(2b+1)b}\right). \text{ Whence}$$
$$\tfrac{1}{2}\log.\left(\frac{b+2}{b}\right)=\mathrm{l}.\frac{2b+3}{2b+1}+\mathrm{l}.\left(1+\frac{1}{(2b+3)(2b+1)b}\right);$$

and, therefore, since this last quantity exceeds unit only by a very minute difference, $\frac{1}{2}\log.\frac{b+2}{2}=$ $\log.\frac{2b+3}{2b+1}+\frac{M}{(2b+3)(2b+1)b}$, where M denotes the modulus of the system. If the number $2b+3$ or $2b+1$ be expressed by N, this small correction will amount but to $\frac{M}{\frac{1}{4}N^3}$ or $\frac{2M}{N^3}$. Consequently $\log.\frac{2b+3}{2b+1}=$ $\frac{1}{2}\log.\frac{b+2}{b}-\frac{2M}{N^3}$. It may hence be computed, that the correction on the first approximation will only reach unit in the last figure for the numbers un-

der 206 in tables of seven places, for those under 2055 in the tables of ten places, and for the numbers under 44286 in tables extending to fourteen places.

The corrections needed in Briggs's *Tables* will therefore correspond to these limits,

35150	— 2	23151	— 7
30706	— 3	22143	— 8
27899	— 4	21290	— 9
25898	— 5	20557	— 10
24372	— 6	19913	— 11

Suppose it were required to find the logarithms of the odd numbers above 300, to seven places of decimals. Assuming the logarithms of the series of half those numbers, let their alternate differences be taken, and these again bisected.

Numbers.	Logarithms.	Alternate Differences.	Their Halves.
150	2.1760913		
151	2.1789769		
152	2.1818436	57523	28761
153	2.1846914	57145	28572
154	2.1875207	56771	28386
155	2.1903317	56403	28201

Hence the logarithms of the doubles are formed by the mere addition of these halves.

Numbers.	Logarithms.
301	2.4785665 28761
303	2.4814426 28572
305	2.4842998 28386
307	2.4871384 28201
309	2.4899585

In this manner, the operation may be continued; but, to prevent any accumulation of errors, the logarithms of the composite numbers should serve as standards, being formed by the addition of the logarithms of their several factors. The logarithms of the intermediate even numbers, 302, 304, 306, 308, and 310, are easily determined by adding .3010300 to the logarithms of 151, 152, 153, 154, and 155.

To extend the process a little farther, let Vlacq's logarithms be computed for the numbers above 4000.

Numbers.	Logarithms.	Alternate Differences.	Their Halves.
2000	3.3010299957		
2001	3.3012470886		
2002	3.3014640731	4340774	2170387
2003	3.3016809493	4338607	2169303
2004	3.3018977172	4336441	2168220
2005	3.3021143770	4334277	2167139

Whence are derived,

Numbers.	Logarithms.
4001	3.8021885514 2170387
4003	3.6023855901 2169303
4005	3.6026025204 2168220
4007	3.6028193424 2167139
4009	3.6030360563

Again, to compute the logarithms in Briggs's Canon.

Numbers.	Logarithms.	Alternate Differences.	Their Halves.
9995	3.99978279845413		
9996	3.99982624745441		
9997	3.99986969210827	8689365404	4344682707
9998	3.99991213241658	8688496217	4344248108
9999	3.99995656838020	8687627193	4343813596
10000	4.00000000000000	8686758342	4343379171
19991	4.30083451916161 4344682696		
19993	4.30087796598857 4344248097		
19995	4.30092140846954 4343813585		
19997	4.30096484660539 4343379161		
19999	4.30100828039700		

The additive parts here consist of those differences diminished by 11 and the last one by 10, since the numbers now approach to the limit 20557.

The first mode of interpolating, thus derived from the nature of logarithms, and so commodious for their computation, might likewise be deduced from general considerations. Let A, B, C, D, E, &c. represent any series of numbers. If they advance regularly and slowly, their first differences, $B—A$, $C—B$, $D—C$, $E—D$, &c. may be viewed as constituting an arithmetical progression. Wherefore the sum of the extremes will be equal to that of the mean terms, or $(E—D) + (B—A) = (D—C) + (C—B)$, that is, $E—A = 2D—2B$, and therefore $D—B = \frac{E—A}{2}$, whence $D = B + \frac{E—A}{2}$. Applying this to the logarithms of eight places of figures, let A, B, C, D, E, &c. represent

the logarithms of 500, 501, 502, 503, 504, &c., then $\log. 503=\log. 501+\frac{\log. 504-\log. 500}{2}=\log. 501+\frac{\log. 252-\log. 250}{2}=2.69983773+\frac{1}{2}(2.40140054-2.39794001)=2.79156799$; the halves of the alternate differences of the logarithms of 250, 251, 252, 253, &c. being thus taken, as before, to compose by their additions the logarithms of the odd numbers 503, 505, 507, &c.

But since $E-A=2D-2B$, it follows that $E=A+2(D-B)$. Wherefore, in any series, the fifth term will be found nearly, by adding to the first term the double the difference between the second and fourth terms. In this way the tables of natural sines, tangents, and secants, could easily be framed. Thus, the logarithmic sines of the successive arcs, 50°, 50° 1′, 50° 2′, and 50° 3′ being from Vlacq's *Tables*, to find the logarithmic sine of 50° 4′.

Arcs.	Logarithmic Sines.	
50° 0′	9.8842539665	
1′	9.8843599396	2117585
2′	9.8844658502	2
3′	9.8845716981	42235170
4′	9.8846774835	

Here, passing over the middle term, the difference between the logarithmic sines of 50° 1′ and of 50° 3′ is doubled, and added to that of 50°, to form the logarithmic sine of 50° 4′.

But a nearer approximation may be obtained, by supposing the second differences of any series to form the arithmetical progression. The sum of the extreme terms $C-2B+A$ and $F-2E+D$ would, therefore, be equal to the sum of the mean terms $D-2C+B$ and $E-2D+C$; whence $F-A=3B+3E-2C-2D$, or $F=A+3(B+E)-2(C+D)$. Thus, the natural sines of the successive arcs 30, 31, 32, 34, and 35 degrees may be easily computed to seven places of figures.

Arcs.	Sines.	
30°	.5000000	
31	.5150381	1.0742310 × 3 = 3.2226930
32	.5299193	1.0745583 × 2 = 2.1491166
33	.5446390	
34	.5592929	Difference 1.07535764
35	.5735764	

The sines of 31° and of 34° are here added together, and the sum tripled, and from this amount is taken the double of the sum of the sines of 31° and of 33°; the sine of 30° being subtracted from that remainder, leaves finally the sine of 35°.

Employing the same number of terms of the series, a still closer approximation may be discovered, by considering the third differences only as uniformly progressive. Wherefore the extreme differences $D-3C+3B-A$ and $F-3E+3D-C$ will be together equal to double the middle one, $E-3D+3C-B$, and consequently $F-A=5E-10D+10C-5B$, or $F=A+5(E-B)-10(D-C)$.

Hence the logarithms even of low numbers may be computed exact to eight decimal places. Thus, the logarithms of 150, 151, 152, 153, and 154, being given, that of 155 is found by this process:

Numbers.	Logarithms.		
150	2.17609126		
151	2.17897695	854377 × 5 =	4271885
152	2.18189359	284784 × 10 =	2847840
153	2.18469143		
154	2.18752072	Difference	1424045
155	2.19033170	Add	2.17609126
			2.19033171

The difference between the logarithms of 151 and 154 is here multiplied by 5, and the difference of the logarithms of 152 and 153 is multiplied by 10; and the excess of the former product above the latter being added to the logarithm of 150, gives the logarithm of 155.

It would obviously be preferable, however, to employ the formula in a modified form for interpolation merely. Hence $D=C+\frac{1}{5}(E-B)+A-F$.

If six terms of the series were given, the seventh could be found to a high degree of accuracy. The sum of the extremes of the progressive third differences being now assumed equal to that of the means, we have $D-3C+3B-A+G-3F+3E-D=E-3D+3C-B+F-3E+3D-C$, and by reduction $G-A=4F-5E-5C-4B$, whence $G=A+4(F-B)-5(E-C)$. It seems unnecessary to subjoin any farther illustrations; but the very simple methods of interpolation now proposed, might be applied with great facility and advantage in various physical researches. In this way, much light may be thrown upon the resistance of fluids, and upon the force, the density, and the component heat of steam, at different temperatures.

(D.)

POPULATION.

England. The Returns of the Census of 1821, as given in the *Abstract* printed by order of the House of Commons, not having been published till this work was nearly finished, it appeared to be proper to insert here such parts of the information contained in that *Abstract,* as are necessary to bring into one point of view, all the material facts connected with the progress and present state of the Population of the British Empire, during the last half century. England.

Counties of England and Wales, their Extent, Population, &c. (See *Population Abstract,* p. 32, and Returns at the end of each County.)

Counties of England.	Square Statute Miles.	Population, 1801.	Increase *per Cent.*	Population, 1811.	Increase *per Cent.*	Population, 1821.	Males, as enumerated in 1821.	Females, as enumerated in 1821.
Bedford	463	65,500	11	72,600	18	85,400	40,385	43,331
Berks	756	112,800	8	122,300	10	134,700	65,546	66,431
Buckingham	740	111,000	10	121,600	13	136,800	64,867	69,201
Cambridge	858	92,300	13	104,500	19	124,400	60,301	61,608
Chester	1,052	198,100	18	234,600	17	275,500	132,952	137,146
Cornwall	1,327	194,500	15	223,900	17	262,600	124,817	132,630
Cumberland	1,478	121,100	14	138,300	15	159,300	75,600	80,524
Derby	1,026	160,500	15	191,700	13	217,600	105,873	107,460
Devon	2,579	354,400	12	396,100	13	447,900	208,229	230,811
Dorset	1,005	119,100	8	128,900	14	147,400	68,934	75,565
Durham	1,061	165,700	11	183,600	15	211,900	99,100	108,573
Essex	1,532	234,000	11	260,900	13	295,300	144,909	144,515
Gloucester	1,256	259,100	14	295,100	16	342,600	160,451	175,392
Hereford	860	92,100	6	97,300	8	105,300	51,552	51,691
Hertford	528	100,800	14	115,400	15	132,400	64,121	65,593
Huntingdon	370	38,800	13	43,700	14	49,800	24,020	24,751
Kent	1,537	317,800	21	385,600	13	434,600	209,833	216,183
Lancaster	1,831	695,100	23	856,000	25	1,074,000	512,476	540,383
Leicester	804	134,400	15	155,100	15	178,100	86,390	88,181
Lincoln	2,748	215,500	14	245,900	17	288,800	141,570	141,488
Middlesex	282	845,400	17	985,100	19	1,167,500	533,573	610,958
Monmouth	498	47,100	36	64,200	13	72,300	37,278	34,555
Norfolk	2,092	282,400	7	301,800	16	351,300	166,892	177,476
Northampton	1,017	136,100	7	146,100	13	165,800	79,575	82,908
Northumberland	1,871	162,300	10	177,900	14	203,000	95,354	103,611
Nottingham	837	145,000	16	168,400	13	190,700	91,491	95,382
Oxford	752	113,200	9	123,200	13	139,800	68,817	68,154
Rutland	149	16,900	1	17,000	11	18,900	9,223	9,264
Salop	1,341	172,200	17	200,800	5	210,300	102,056	104,097
Somerset	1,642	282,800	11	313,300	16	362,500	170,199	185,115
Southampton	1,628	226,900	12	253,300	14	289,000	138,373	144,925
Stafford	1,148	247,100	23	304,000	14	347,900	171,668	169,372
Suffolk	1,512	217,400	12	242,900	14	276,000	132,410	138,132
Surrey	758	278,000	20	334,700	22	406,700	189,871	208,787
Sussex	1,463	164,600	19	196,500	21	237,700	116,705	116,314
Warwick	902	215,100	10	236,400	18	280,000	133,827	140,565
Westmoreland	763	43,000	10	47,500	10	52,400	25,513	25,846
Wilts	1,379	191,200	5	200,300	13	226,600	108,213	113,944
Worcester	729	143,900	15	165,900	13	188,200	90,259	94,165
York								
East Riding		144,000	20	173,000	12	194,300	92,761	97,688
North Riding	5,961	160,500	7	171,100	10	187,400	90,153	93,228
West Riding		582,700	16	675,100	21	815,400	397,542	401,815
ENGLAND	50,535	8,609,000	$14\frac{3}{5}$	9,870,300	$16\frac{2}{5}$	11,486,700	5,483,679	5,777,758

Wales.

Wales.

Counties of Wales. (See *Population Abstract*, p. 34, and County Returns.)

Counties of Wales.	Area in Square Miles English.	Population, 1801.	Increase *per Cent.*	Population, 1811.	Increase *per Cent.*	Population, 1821.	Males, as enumerated in 1821.	Females, as enumerated in 1821.
Anglesey	271	35,000	10	38,300	20	46,000	21,784	23,279
Brecon	754	32,700	19	39,000	14	44,500	21,853	21,760
Cardigan	675	44,100	18	52,000	13	59,000	27,898	29,886
Carmarthen	974	69,600	15	79,800	15	92,000	43,577	46,662
Carnarvon	544	43,000	19	51,000	16	59,100	28,412	29,546
Denbigh	633	62,400	6	66,400	18	78,000	37,785	38,726
Flint...............	244	41,000	17	48,100	14	54,900	26,733	27,051
Glamorgan	792	74,000	19	88,000	18	103,800	50,427	51,310
Merioneth	663	30,500	5	32,000	9	35,100	16,479	17,903
Montgomery ...	839	49,300	9	53,700	14	61,100	29,743	30,156
Pembroke	610	58,200	8	62,700	20	75,500	34,530	39,479
Radnor	426	19,700	10	21,600	8	23,500	11,266	11,193
WALES......	7,425	559,000	13	632,600	16	731,800	350,487	366,951

Note.—These numbers include the estimated proportions of the Army and Navy belonging to each county, at the respective periods of taking the Census; but the *Actual Total* in England, in 1821, was 11,261,437; in Wales it was 717,438; and in Scotland it was 2,093,456; as then enumerated, and as is shown in these Summaries, by the numbers of Males and Females.

THE METROPOLIS.

The rapid increase of the population in the suburbs, since the beginning of the last century, shows how rapidly the metropolis increases in extent, although its population has not increased so fast as that of the nation at large. In 1700, the metropolis contained almost an eighth part of the inhabitants of England and Wales; in 1750 and in 1801, about a tenth part; but in 1811 and at present, only about a twelfth part.

Objections might be made to the propriety of the limits of the metropolis as herein assumed, and it may therefore be right to add, that the population of all the parishes, of which the churches are situate within eight miles rectilinear around St Paul's Cathedral (including the before mentioned addition of one twenty-fifth part), would, in 1801, have amounted to 1,031,500;—in 1811, to 1,220,200;—and in 1821, to no less than 1,481,500; without including the parish of Woolwich, which contains 17,008 additional.

N. B. The population ascribed to the city of Paris is comprised within a district of full such an extent.

The arrivals of coasting vessels in the port of London may be estimated to have been about 5500, in the year 1700;—6400, in the year 1750;—10,400, in 1801;—13,500, in 1811; and at about 17,000 *per annum*, since the year 1817. This produces a constant, though fluctuating accession to the population, to a larger amount than elsewhere, and consequently, a twenty-fifth, instead of a fiftieth part, is to be added to form a comparison with the Parish Register Returns in the General Abstract. With this addition, the metropolis, in the year 1801, contained about 900,000;—in 1811, about 1,050,000;—and in 1821, about 1,274,800 inhabitants. The totals would then be, in

	1700.	1750.	1801.	1811.	1821.
	674,350	676,250	900,000	1,050,000	1,274,800
The actual totals, as enumerated, were			864,845	1,009,546	1,225,694

Comparison of the Population of the Shires of Scotland. (See *Population Abstract*, p. 34, and Returns at the end of each County.)

Shires of Scotland.	Population, 1801.	Increase *per Cent.*	Population, 1811.	Increase *per Cent.*	Population, 1821.	Males, as enumerated in 1821.	Females, as enumerated in 1821.
Aberdeen	127,200	10	139,600	14	158,500	72,383	83,004
Argyle	74,300	19	88,400	12	99,300	47,775	49,541
Ayr	87,100	23	107,400	21	129,800	61,077	66,222
Banff	37,000	2	37,900	17	44,400	20,193	23,368
Berwick	31,600	1	31,800	7	34,100	15,976	17,409
Bute	12,200	2	12,400	13	14,100	64 74	7,323
Caithness	23,400	4	24,200	27	30,800	14,196	16,042
Clackmannan	11,200	11	12,400	9	13,500	6,356	6,907
Dumbarton	21,400	17	25,000	11	27,900	13,046	14,271
Dumfries	56,400	15	65,100	11	72,300	33,572	37,306
Edinburgh	127,100	21	153,600	27	195,300	87,759	93,755
Elgin	27,600	5	29,000	9	31,800	14,292	16,870
Fife	96,900	8	104,600	12	116,800	53,540	61,016
Forfar	102,400	8	110,800	4	115,700	52,071	61,359
Haddington	31,000	4	32,200	11	35,800	16,828	18,299
Inverness	76,800	5	80,900	14	92,000	42,304	47,853
Kincardine	27,200	4	28,400	5	29,700	13,540	15,578
Kinross	6,900	8	7,500	6	7,900	3,660	4,102
Kirkcudbright	30,200	15	34,800	14	39,700	18,506	20,397
Lanark	151,600	31	198,100	26	249,300	115,385	129,002
Linlithgow	18,400	9	20,100	15	23,100	10,703	11,982
Nairn	8,500	...	8,500	8	9,200	4,082	4,924
Orkney & Shetland	48,400	...	47,700	14	54,200	24,070	29,054
Peebles	9,000	14	10,300	...	10,200	4,973	5,073
Perth	130,600	7	139,600	2	141,800	66,033	73,017
Renfrew	80,700	19	96,100	19	114,400	51,178	60,997
Ross & Cromarty	57,200	10	62,900	12	70,200	32,324	36,504
Roxburgh	34,800	11	38,500	8	41,700	19,408	21,484
Selkirk	5,200	16	6,100	11	6,800	3,205	3,432
Stirling...............	52,500	15	60,200	11	66,700	31,718	33,658
Sutherland	23,900	2	24,400	...	24,300	11,088	12,752
Wigtown	23,700	17	27,800	22	33,900	15,837	17,403
SCOTLAND...	1,652,400	13	1,865,900	$14\frac{1}{2}$	2,135,300	983,552	1,109,904

Ireland.

Ireland.

Comparative Abstract of the Population, &c. of Ireland, according to the Two Censuses made in 1813 *and in* 1821. (*Parliamentary Paper.*)

Counties, &c. in Ireland.	No. of Houses in 1813.	No. of Houses in 1821.	No. of Inhabitants in 1813.	No. of Inhabitants in 1821.	Increase since 1813.
Connaught .... *total*	...	191,267	...	1,053,918	...
Galway........................	21,122	51,484	140,995	286,921	145,926
Galway, Town............	3,353	4,185	24,684	27,827	3,143
Leitrim	17,899	19,123	94,095	105,976	11,881
Mayo.........	43,702	53,940	237,371	297,538	60,167
Roscommon................	30,254	38,289	158,110	207,777	49,667
Sligo	no return.	24,246	no return.	127,879	...
Leinster............... *total*	...	284,673	...	1,785,702	...
Carlow	12,090	13,854	69,566	81,287	11,721
Drogheda, Town	3,086	3,463	16,123	18,118	1,995
Dublin	16,633	21,987	110,437	160,274	49,837
Dublin, City.........	15,104	16,005	176,610	186,276	9,666
Kildare........................	14,564	15,875	85,133	101,715	16,582
Kilkenny	23,414	26,479	134,664	157,096	22,432
Kilkenny, City.............	no return.	4,321	no return.	23,230	...
King's County..............	19,705	23,032	113,226	132,319	19,093
Longford	16,348	17,320	95,917	107,702	11,785
Louth	no return.	17,428	no return.	101,070	...
Meath	25,921	30,432	142,479	174,716	32,237
Queen's County	19,932	23,067	113,857	129,391	15,534
Westmeath	no return.	[illegible]	no return.	128,042	...
Wexford	no return.	29,513	no return.	169,304	...
Wicklow	13,445	18,419	83,109	115,162	32,053
Munster .... *total*	...	...	...	2,005,363	...
Clare	29,301	36,312	160,603	209,595	48,992
Cork	91,447	...	523,936	702,000	...
Cork, City	7,652	12,175	64,394	100,535	36,141
Kerry	31,749	34,612	178,622	205,037	26,415
Limerick	17,897	36,089	103,865	214,286	110,421
Limerick, City	no return.	8,268	no return.	66,042	..
Tipperary	50,224	60,200	290,531	353,402	62,871
Waterford......................	19,342	21,493	119,457	127,679	8,222
Waterford, City	3,581	4,052	25,467	26,787	1,320
Ulster .... *total*	...	...	...	2,001,966	...
Antrim.........................	42,258	...	231,548	261,601	30,053
Armagh	21,944	37,714	121,449	196,577	75,128
Carrickfergus, Town ...	1,166	1,444	6,136	8,255	2,119
Cavan	no return.	34,744	no return.	194,330	...
Donegal	no return.	46,000	no return.	249,483	...
Down	53,310	62,425	287,290	329,348	42,058
Fermanagh	19,291	22,912	111,250	130,399	19,149
Londonderry	31,287	33,913	186,181	194,099	7,918
Monaghan	27,066	33,197	140,433	178,183	37,750
Tyrone.........................	46,213	...	250,746	259,691	8,945
SUMMARY. Connaught	...	191,267	...	1,053,918	...
Leinster	...	284,673	...	1,785,702	...
Munster	...	...	...	2,005,363	...
Ulster	...	...	...	2,001,966	...
IRELAND.......	...	...	...	6,846,949	...

Population.

The Numbers of Marriages, Baptisms, and Burials, recorded, in England and Wales, have been as follow, for the last Twenty Years. (From *Parish Register Abstract*, p. 154.)

Years.	Marriages.	Baptisms.	Burials.
1801	67,228	237,029	204,434
1802	90,396	273,837	199,889
1803	94,379	294,108	203,728
1804	85,738	294,592	181,177
1805	79,586	292,201	181,240
1806	80,754	291,929	183,452
1807	83,923	300,294	195,851
1808	82,248	296,074	200,763
1809	83,369	299,989	191,471
1810	84,470	298,853	208,184
1811	86,389	304,857	188,543
1812	82,066	301,954	190,402
1813	83,860	314,432	186,477
1814	92,804	318,806	206,403
1815	99,944	344,931	197,408
1816	91,946	330,199	205,959
1817	88,234	331,583	199,269
1818	92,779	331,384	213,624
1819	95,571	333,261	213,564
1820	96,833	343,660	208,349

The Numbers of Marriages as estimated for Five and Ten Years, have been as follow. (*Abstract*, p. 25.)

Periods.	Medium Average of Five Years.	Medium Average of Ten Years.
1755 to 1760 inclusive	52,666	56,275
1760 — 1765 ——	59,883	
1765 — 1770 ——	59,043	59,892
1770 — 1775 ——	60,741	
1775 — 1780 ——	64,238	65,479
1780 — 1785 ——	66,722	
1785 — 1790 ——	71,363	71,784
1790 — 1795 ——	72,205	
1795 — 1800 ——	74,998	79,231
1800 — 1805 ——	83,465	
1805 — 1810 ——	82,953	85,985
1810 — 1815 ——	89,012	
1815 — 1820 ——	93,073	

General Summary of Houses, Families, and Persons, in 1821, *in Great Britain, &c.*

	England.	Wales.	Scotland.	Army, Navy, and Seamen.	Great Britain.
Number of Houses	2,036,317	140,820	356,536	...	2,533,673
Number of Families ...	2,346,717	146,706	447,960	...	2,941,383
Persons, Males	5,483,679	350,487	983,552	319,300	7,137,018
Persons, Females	5,777,758	366,951	1,109,904	...	7,254,613
Total of Persons...	11,261,437	717,438	2,093,456	319,300	14,391,631
Total of Persons in Ireland........................					6,846,949
Total of Persons in the Islands of the British Seas					92,122
Grand Total of the Population of the British Islands, in 1821...					21,330,802

Summary and Comparative Statement of the Enumerations of 1801, 1811, *and* 1821. (*Abstract*, p. 8.)

	Population, 1801.	Increase *per Cent.*	Diminution *per Cent.*	Population, 1811.	Increase *per Cent.*	Diminution *per Cent.*	Population, 1821.
England	8,331,434	$14\frac{1}{2}$	...	9,538,827	18	...	11,261,437
Wales	541,546	13	...	611,788	$17\frac{1}{3}$	...	717,438
Scotland	1,599,068	13	...	1,805,688	$15\frac{6}{7}$	...	2,093,456
	10,472,048	14	...	11,956,303	$17\frac{2}{3}$	...	14,072,331
Army, Navy, &c.	470,598	36	...	640,500	...	50	319,300
Totals......	10,942,646	15	...	12,596,803	$14\frac{1}{4}$	...	14,391,631

The Censuses were taken as directed by the respective Acts on the 10th of March, in the year 1801; on the 27th of May, in the year 1811; and on the 28th of May, in the year 1821.

REFRACTION, DOUBLE, AND POLARISATION OF LIGHT.*

Polarisation of Light.

UNTIL a very few years since, the greater number of natural philosophers, and almost all mathematical opticians, were agreed in considering the rays of light as composed of extremely minute molecules, darted, in every possible direction, by a luminous body, with very great velocities. The form of these molecules remained undetermined; but as it was inferred from some observations, made long ago, that certain rays had not the same properties in every part of their circumference, it was natural to compare them to little magnets, and to suppose them possessed of poles. Hence the appellation of a *polarised ray* was applied to every ray of light, so modified, as to exhibit the polar properties of its molecules. We shall begin this article by describing the different methods that have been discovered for obtaining polarised rays.

SECT. I.—*Of* DOUBLE REFRACTION, *considered as a Mode of* POLARISING *Light.*

Supposing a pencil of *natural light*, that is to say of light coming directly from a luminous body, without having undergone any change by refraction or by reflection, to fall upon a crystal of carbonate of lime, perpendicularly to one of its surfaces, either natural or artificial: this pencil will in general undergo a bifurcation as it enters the crystal; one half of the incident light continuing its course in a right line, according to the ordinary laws of refraction, and the other exhibiting a very remarkable phenomenon, and assuming an oblique direction, notwithstanding its original perpendicularity. The former half is called the *ordinary pencil* or ray, the latter the *extraordinary pencil or ray.* The plane passing through these two pencils must obviously be perpendicular to the surface of the crystal; this plane is of great importance in the phenomena of polarisation, and it is denominated the *principal section* of the crystal.

According to this definition, it appears that every ray of light, at each point of incidence on a given crystal, will have a principal section corresponding to it; and we have only to observe that all these sections will be parallel to each other. In a rhomboid of Iceland spar, the principal section cuts the natural faces of the crystal in a line parallel to the diagonal joining the obtuse angles of the parallelogram, and dividing it into two equal parts.

Now, the *ordinary* and *extraordinary* rays both *acquire* within the crystal *new properties*, not inherent in the direct light.

In order to show this, it will be sufficient to remark what happens to these rays when they fall on a second crystal which has the properties of double refraction: and, first, with respect to the ordinary ray, which has preserved its rectilinear direction without deviation.

Polarisation of Light.

If the principal section of the second crystal *is parallel* to the principal section of the first, the ray will undergo no double refraction in the second, but will continue its course without any subdivision. But if the principal sections of the two crystals are perpendicular to each other, the ray which was *ordinarily* refracted in the *first* crystal, will become an *extraordinary* ray in the *second;* and will be refracted obliquely when its incidence is perpendicular. But when the principal sections are neither perpendicular nor parallel to each other, this same ordinary ray will be subdivided in the second crystal, but its portions will be of different intensities, except when the sections form an angle of 45° with each other.

The extraordinary pencil exhibits phenomena of a similar nature. It remains an extraordinary pencil in every crystal of which the principal section is parallel to that of the crystal which has transmitted it, and becomes an ordinary pencil when the principal sections are at right angles to each other; it is subdivided into two pencils of equal intensity, if the two sections make an angle of 45° with each other, and in every other position, into two pencils of unequal intensities.

It is very easy to verify these propositions by experiment. We place on a horizontal table a piece of black paper, and draw two very fine lines at right angles to each other, with a white spot of a certain magnitude at their intersection; and we lay on the paper a rhomboid of calcarious spar, and with our eye immediately above the spot we see two images of it, situated in a line parallel to the shorter diagonal of the upper face of the rhomboid. One of these images is seen in the true place of the spot, as is easily ascertained by two lines which cross in it, and of which the portions not covered by the crystal point at it; these rays have therefore undergone no deviation, and have been ordinarily refracted. The other rays have been bent, since they do not pass through the true place of the spot, and therefore afford the extraordinary image.

We now place a second crystal on the first, in such a manner that the shorter diagonals of the faces in contact may be parallel: we still find only two images of the white spot, but they are more remote from each other. The one retains its natural situation, whence it follows, that the rays which afford it are no more deflected from their course in the second crystal than they are in the first, and that they have always remained ordinary rays. With regard to the second image, since it is more remote from the true place of the object than when seen through the first crystal only, it is obvious that the rays, which have al-

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* This article has been obligingly furnished by M. ARAGO, and has been translated, with some additions, by a distinguished friend, already well known to our readers. The state of the author's health will, it is hoped, be received as an apology for the very great and unexpected delay which has taken place in the completion of his undertaking.—ED.

ready been extraordinarily refracted in the lower rhomboid, have undergone the same kind of refraction in passing through the upper.

If we only turn the upper rhomboid round the vertical line, so as to remove its principal section from its parallel position, each of the two images will be subdivided into two others. The new images will at first be very weak; their intensity will augment by degrees at the expense of the original images, in proportion as the angle formed by the two sections becomes greater; and at last, when it is a right angle, the two primitive images will have disappeared, and the new images alone will remain. One of them will be at a distance from the true place of the spot, in the direction of the shorter diagonal of the upper rhomboid, about equal to the result of the double refraction of the second crystal if it were separate from the first. This image is therefore formed by rays which have been refracted ordinarily in the first crystal, and extraordinarily in the second. And it will be equally manifest that the other image is derived, on the contrary, from rays refracted at first extraordinarily and then ordinarily, in the respective crystals.

As it is difficult to procure very thick rhomboids of carbonate of lime that are quite transparent, the same experiments may be performed by means of two prisms, cut out of doubly refracting crystals, and rendered achromatic by combining them with prisms of common glass, placed with their bases in opposite directions. Through two such achromatic prisms, placed on each other, the image of a candle appears quadruple or double, according to the relative positions of the principal sections: we thus see very distinctly that the images which disappear are not confounded with the other two, but that they become fainter gradually, while the others increase in intensity by the same degrees.

It appears then, first, that the direct light is *always divided* into two pencils in its passage through the natural faces of a crystal of carbonate of lime: and on the contrary that the light of which either of the two pencils is composed, when submitted to the action of such a crystal, in *some particular positions* of the principal section, *is not divided*, and gives but a single pencil.

Secondly, the two images furnished by the direct light have always an *equal degree* of brightness; but the light of the ordinary or extraordinary pencils, when it undergoes a further double refraction, gives almost always images of unequal intensities.

Hence it follows that in the act of double refraction, this last light has received some new properties, by which it may always be distinguished from natural light.

But are these properties necessarily of such a nature as to be inexplicable without supposing the elementary molecules of the rays to possess certain poles? This is a question which we are now to examine.

We will suppose that a rhomboid of carbonate of lime is placed horizontally: that the incident light falls perpendicularly on its upper surface, and that the principal section, which will be vertical, is in the plane of the meridian, or that it runs north and south: observing, however, that these directions are only chosen to facilitate our comprehension of the facts.

The ordinary pencil afforded by this crystal, when it is submitted to the action of a new rhomboid similarly placed, that is to say, having also its principal section in the plane of the meridian, passes through it, as we have seen, without lateral refraction, and continues its course in a right line, remaining as an ordinary ray.

But when the principal section of the second crystal, being still vertical, is directed from east to west, the ordinary ray, transmitted by the first crystal, will be refracted laterally in it, although it falls perpendicularly on the surface, and will become an extraordinary ray.

In the first case, the principal section of the second rhomboid intersected the ray, or the luminous molecules supposed to compose it, from north to south; in the second, these molecules were intersected from east to west. It may be remarked, that this is the only circumstance in which the cases differ from each other, the ray falling in both cases on the same point of the crystal, and in the same angular direction. It must therefore be concluded, that in the ray of light, or in the elements of which it is formed, the north and south sides must have different properties from those of the east and west.

When we analyse the extraordinary pencil with the second crystal, if the principal section intersects this pencil from north to south, it undergoes the extraordinary refraction, but it follows the ordinary course when this same plane intersects it from east to west; which is exactly the contrary of what occurs with the ordinary pencil. The north and south sides of this pencil have therefore the properties of the east and west sides of the extraordinary pencil, and the reverse: nor is there any other difference between the pencils: the sides possessed of similar properties are only differently directed: so that if we could cause an extraordinary ray transmitted by any crystal to make a quarter of a revolution on itself, it would be impossible to distinguish it from the ordinary ray that has been separated from it.

When natural philosophers say of a loadstone or a magnet that it has poles, they merely understand, by this expression, that certain points about the circumference of the magnet possess properties which do not belong, either at all, or in the same degree, to the other parts of the circumference. It was then equally correct to say of the ordinary and extraordinary rays derived from the subdivision of natural light, in the crystals of carbonate of lime, that they had *poles*, or were *polarised*. It is only necessary to remark, in order to avoid extending the analogy between the rays of light and the magnet, beyond its proper bounds, that for every element of the ray, the sides or poles diametrically opposite to each other, that is, in the position here supposed for illustration, the north and south poles of the ordinary ray, appear both to possess exactly the same properties; and it is at the angular distance of 90° from these points, that is, on a perpendicular to the line that joins them, that we find in the same ray poles possessed of different properties: and if we compare with each other the two pencils transmitted by a given crystal, the poles pos-

sessed of the same properties will be situated in directions perpendicular to each other.

Let us once more consider the two rays transmitted by a crystal of which the principal section is supposed to be in the plane of the meridian. There is no reason whatever for assigning the denomination of poles to the north and south sides of the ordinary ray rather than to the east and west; but as it is necessary to make some distinction, it has been generally agreed to apply the name of poles to the north and south sides. Hence it has been usual to say, that the *ordinary ray* is polarised in the *plane of the principal section:* which is as much as to say that the different elements of the ray have the faces, which we have called poles, situated in that plane. The *extraordinary ray is polarised perpendicularly to the principal section:* its poles are situated perpendicularly to that plane, since it becomes perfectly similar to the ordinary ray, when it is made to describe a fourth of a revolution round itself.

When we have arrived thus far, it becomes natural to ask whether we are to suppose that the separation of the light within the crystal has *given* poles to the molecules, or that the poles, already *preexisting,* have merely been turned towards the same points of space. This question is a very difficult one: but we shall find hereafter, if not a demonstration of the second hypothesis, at least some plausible reason for adopting it. It will here be sufficient to remark, that the modification, undergone by the rays, is entirely independent of the nature of the crystal, provided that it only produce a double image; and that the phenomena presented by two rhomboids of calcarious spar, placed on each other, would be reproduced, with their minutest details, if we combined, for example, one of these rhomboids with a crystal of carbonate of lead: or if the first crystal were of sulphur and the second of quartz, or of sulphate of barita.

But it is not only in the phenomena of double refraction that the particular properties of polarised rays are exhibited: the *reflection* of these rays, at the surfaces of *transparent bodies,* affords also a method of *distinguishing* them from *common light.*

When a pencil of natural light falls on a transparent mirror with any inclination whatever, it is divided into two parts; the one passes through the substance of the mirror, the other is reflected. This latter portion is always found in the plane, passing through the primitive pencil, and the line perpendicular to the surface; which is called the *plane of reflection,* and which must be carefully distinguished from the *reflecting surface.*

If we now place the principal section of a doubly refracting crystal in a vertical position, and throw a pencil of common light perpendicularly on its surface, receiving the two emerging pencils on the horizontal surface of some water: and let us suppose the ordinary pencil to make with the surface of the liquid an angle of 37° 15′; [the crystal being held in a position inclined to the horizon]: this pencil will undergo a partial reflection like the direct light, while the extraordinary pencil, when its angle of incidence is also 37° 15′, will *enter the liquid completely, without the reflection of any of its molecules:* a character which constitutes a marked distinction between this pencil and the natural light.

All other circumstances of the experiment remaining the same, let us now cause the crystal to make one fourth of a revolution round the incident pencil, so as to bring the principal section into a position perpendicular to its first situation: we shall then find that the ordinary pencil alone will be entirely transmitted by the liquid; the other will undergo a partial reflection, exactly equal to that which we had first observed in the ordinary ray: the experiment affording a new proof, that the two rays only differ in the direction, which is assumed by their corresponding sides.

We find also that in all positions of the principal section, intermediate between these two, the two pencils will both undergo a partial reflection so much the stronger, for the ordinary pencil, as the principal section is the nearer to a coincidence with the plane of reflection, and for the extraordinary pencil, as these planes are more nearly perpendicular to each other.

We shall finish this section with an account of the mathematical law which appears to determine the comparative intensities of the ordinary and extraordinary pencils into which polarised light is separated, when it is analysed with a doubly refracting crystal. Let F_o be the intensity of the ordinary pencil transmitted by any crystal, and F_{oo} and F_{oe} the intensities of the ordinary and extraordinary pencil derived from it in passing through the second crystal: let i be the angle formed by the two principal sections: then we shall have $F_{oo}=F_o \cos^2 i$; $F_{oe}=F_o \sin^2 i$.

In particular cases we shall have from these formulas, if $i=0$, $F_{oo}=F_o$, $F_{oe}=0$; if $i=90°$, $F_{oo}=0$, $F_{oe}=F_o$; and if $i=45°$, $F_{oo}=\frac{1}{2}F_o$; $F_{oe}=\frac{1}{2}F_o$.

These three consequences of the formula, as we have seen, are conformable to observation. It will not however be proved to be mathematically exact, until we have also verified it for some values of i, intermediate between these limits.

The formulas belonging to the extraordinary ray are equally simple: F_e being the intensity of this ray, and F_{eo} and F_{ee} those of the two ordinary and extraordinary pencils into which it is divided by the crystal, i preserving its former signification, we shall have $F_{eo}=F_e \sin^2 i$, and $F_{ee}=\cos^2 i$. If $i=0$, $F_{eo}=0$, and $F_{ee}=F_e$; and in fact there is no ordinary ray in this case, the whole light following the extraordinary path: if $i=90°$, $F_{eo}=F_e$, and $F_{ee}=0$: which is again confirmed by observation, since the extraordinary ray, coming from a certain crystal, follows only the ordinary course in passing through another, of which the principal section is perpendicular to that of the first. The same agreement between the calculation and the experiment will be found when $i=45°$; which, however, does not supersede the necessity of verifying these formulas, as well as the former, by direct experiments at intermediate angles.

SECT. II.—*Of* REFLECTION, *considered as a mode of Polarising Light.*

Reflection, at the surface of a transparent body,

affords, as we have seen, a *criterion* for the distinction of polarised from ordinary rays; we must also add, that such a reflection is also capable of polarising ordinary light.

Throwing, for example, a pencil of natural rays on a mirror of common glass in a horizontal position, in such a manner that the inclination of the ray to the surface may be about 35°: we shall find that a part of the pencil will pass through the glass; the other part will be reflected; and the reflected portion will be polarised in the same manner as the ordinary pencil transmitted by a crystal, of which the principal section coincides with the plane of reflection.

In fact, if we analyse the light, thus partially reflected, by the assistance of a crystal, of which the principal section coincides with the plane of reflection, it is not subdivided, and affords only a single ordinary image. Nor is it again subdivided in passing through the crystal, when the principal section is perpendicular to the plane of reflection; but in this case it only affords an extraordinary image. In every other position we have both an extraordinary and an ordinary image, the intensity of the latter being expressed by the formula, $F \cos^2 i$: in which F is the total intensity of the pencil subjected to the experiment, and i the angle formed by the principal section of the crystal with the plane of reflection. This formula obviously coincides with that which we have given for the ordinary pencil in the case of two crystals combined. The plane of reflection here performs the office of the principal section of the first crystal; it is therefore in this plane that the ray has become polarised by the reflection.

Before we assert, however, that there is an identity in the species of polarisation effected by partial reflection with given inclinations, at the surface of a transparent body, and that which results from double refraction, we must submit the ray polarised by a first reflection to the test of new reflections.

These second reflections will obviously throw the light downwards if the mirror is above the ray, or upwards if below; from right to left, if the mirror receives the ray on its [left hand] surface, and the reverse if on the [right] surface.

Now, if the second mirror is above or below the ray, so that the new plane of reflection coincides with the old, there is a partial reflection at all incidences. But when, on the contrary, this mirror is presented to the ray on the left or the right side, and in such a manner that the new plane of reflection may be perpendicular to the old one, all reflection ceases at the inclination of about 35°, already mentioned. In the intermediate positions of the mirror, and with the constant inclination of 35°, the intensity of the reflection varies in proportion to the square of the cosine of the angle formed by the two planes of reflection with each other.

The least attention will show how much analogy this experiment has with those which have been made with a rhomboidal crystal. In those experiments, in order to see if the ordinary ray had the same properties with respect to each point of its circumference, we caused the crystal to revolve round the ray as an axis, so as to bring in succession its principal section, and consequently the poles contained in it, into a vertical direction, from right to left, and so forth; in these different positions we threw the ray on a transparent substance. Here, we left the first plane of reflection immoveable, and the second turned round the ray, which was thrown on its different sides. This trial is evidently similar to the former, and the result is identical.

We may therefore now affirm, that the ray which is reflected at the upper surface of the glass, with an inclination of about 35°, possesses in all respects the same properties as a ray transmitted by a crystal, of which the principal section coincides with the plane of reflection.

We have supposed the substance employed in this experiment to be transparent; but we must add, that some opaque bodies, such as black marble, ebony, and some varnishes, possess in an equal degree the property of polarising rays which are reflected at their surface. These substances, when made to revolve round a polarised ray, exhibit the same effect, with regard to the reflected light, as the transparent substances which have been considered.

Sect. III.—*Of Rays* PARTIALLY *Polarised.*

Rays partially polarised are those which possess properties that may be called intermediate between the properties of ordinary light and of light completely polarised. They are distinguished from polarised light by affording always two pencils, in their passage through a crystal possessed of the property of double refraction: they differ from natural light in not affording always two pencils of the same intensity, in all positions of the principal section of the same crystal.

It may be asked, if a ray partially polarised may not be considered as consisting of a portion, A, of polarised and a portion, B, of natural light. This latter portion would *always* be equally divided into an ordinary and an extraordinary pencil, in its passage through a crystal possessing the properties of double refraction; the other would pass *sometimes* entirely as an ordinary or an extraordinary pencil. In a certain position of the principal section, therefore, the comparative intensities of the two pencils would be $\frac{1}{2}B+A$, and $\frac{1}{2}B$; and after one fourth of a revolution, they would become $\frac{1}{2}B$, and $\frac{1}{2}B+A$ respectively. In all other positions, A would be divided between the two images: the portion belonging to the ordinary image being expressed by $A \cos^2 i$, i being the angle contained by the plane of polarisation of A and the principal section of the crystal: and when $i=45°$, the two images would be of equal intensity.

All these consequences of the hypothesis, that we have assumed, are conformable to experiment: and we may therefore suppose that a ray partially polarised is composed of two separate portions, the one, B, in its natural state, the other, A, totally polarised. [Dr Brewster's experiments on partial polarisation will be mentioned hereafter.]

In every pencil reflected perpendicularly by a transparent substance, the portion A vanishes: it acquires greater and greater values in proportion as the angle of incidence increases; but at the angular situation of complete polarisation B vanishes, and

A comprehends the whole pencil. Still farther from the perpendicular, we find again in the pencil natural light, B, and polarised light, A. Lastly, when the incident and reflected light sweeps, as it were, the surface of the mirror, A is again very inconsiderable with respect to B.

Metallic mirrors do not completely polarise the rays that they reflect at any angle of incidence. As in the case of transparent substances, A is evanescent for perpendicular rays; but it becomes sensible in every other case, and the light becomes partially polarised. The angle of polarisation of a metal is that which makes the quotient $\frac{A}{B}$ a maximum.

There exist also some transparent bodies, such as the diamond and sulfur, which never produce complete polarisation of the light that is reflected at their surfaces; but the quotient $\frac{A}{B}$ acquires, at least, much greater values for their substances than for the metals.

The mathematical law, which connects the value of A with that of the angle of incidence, and of the refractive form of the mirror, has not yet been discovered. It is only known, that at regular angular distances above and below the angle of complete polarisation, the proportion of A to $A+B$ is nearly the same, although the absolute value of A and B may have changed very considerably.

Thus, in the case of the glass of St Gobin, for example, in which the complete polarisation takes place when the inclination of the ray to the surface is about 35°, we find that the reflected pencils contain the *same proportion* of polarised light at the following angles:

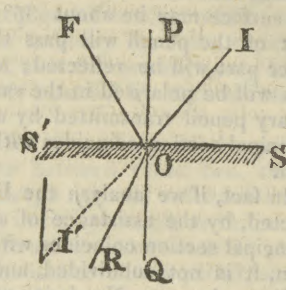
	65°	42′	63°	54′	60°	18′
and	7	12	7	55	11	40
mean	36	27	35	55	35	59

For water, the relation of A to $A+B$ is nearly the same at the angles 3° 29′ and 73° 48′: the mean of these, 38° 36′, exceeds by $1\frac{1}{4}$° only the true inclination of complete polarisation, though it is deduced from angles which differ from it more than 30°.

In the same manner, therefore, as astronomers determine the instant of the passage of a luminary over the meridian, by corresponding altitudes, observed before and after that passage, we may obtain, with tolerable precision, the angle of complete polarisation, by taking the half sum of the inclinations corresponding to equivalent partial polarisations, especially if we take care not to deviate too far from the angle required: and this method has its advantages, when we make the experiment on bodies which do not polarise the rays of light completely at any incidence.

SECT. IV.—*Of the Laws which connect the* REFRACTIVE DENSITIES *of Bodies with the Angles of Polarisation.*

It is sufficient to look over the tables which have been published, of the angles of complete polarisation for rays reflected by substances of various kinds, in order to observe that these angles, reckoned from the perpendicular, approach so much the more to right angles, as the refractive densities of the substances are greater; but it was not so easy to detect the remarkable connexion which exists between these two elements, and which we shall now proceed to examine.



When a ray of light, IO, passes from a vacuum into a certain medium, SS′, it is refracted at the point of incidence O, approaches to the perpendicular PQ, and follows, for example, the direction OR; the angles POI and QOR being for each medium connected by the proportion sin POI : sin QOR$=m$: 1, in which the quantity m is constant for all values of the angles. This quantity, which is always greater than unity, has been called the *index of refraction*, appropriate to the medium. It is necessary to distinguish it carefully from the refractive *power*, a numerical expression depending on m, and on the density, and chiefly relating to the particular properties attributed to refractive substances in the theory of emission.

This being understood, if the angle of incidence be supposed such, that the reflected ray OF may be completely polarised, it is found, that *the tangent of the angle of incidence will be equal to the index of refraction.*

In the following table, the angles of polarisation, determined by experiment, are compared with those which result from the general law; and the errors are not greater than may be attributed to the unavoidable error of observation.

Substances.	Observed Angle.		Computed Angle.		Difference.
Air,	45° to 47°		45°		[1°]
Water,	52°	45′	53	11′	—26′
Fluor spar,	54	50	55	9	—19
Obsidian,	56	3	56	6	—3
Sulfate of lime,	56	28	56	45	—17
Rock crystal,	57	22	56	58	+24
Topaz,	58	40	58	34	+6
Iceland crystal,	58	23	58	51	—28
Ruby spinel,	60	16	60	25	—9
Zircon,	63	8	63	0	+8
Glass of antimony,	64	45	64	30	+15
Sulfur,	64	10	63	45	+25
Diamond,	68	2	68	1	+1
Chromate of lead,	67	42	68	3	—21

This law is capable of being expressed in two other remarkable forms.

Since in all cases sin POI : sin QOR$=m$: 1, we have universally sin POI$=m$ sin QOR: but for the angle of complete polarisation tang POI$=m$, and since tang$=\frac{\sin}{\cos}$, $\frac{\sin \text{POI}}{\cos \text{POI}}=m$, and sin POI$=m$ cos

$POI = m \sin QOR$, and $\sin QOR = \cos POI$, consequently, $QOR + POI = 90°$; hence, *when the polarisation is complete, the inclination of the incident ray to the surface is equal to the angle of refraction; and the reflected and refracted rays are perpendicular to each other.*

It is of consequence to examine some objections which have been made to the accuracy of the law in question. If it were mathematically accurate, the rays of different colours, it has been observed, would not be polarised exactly at the same time; since they enter the refractive medium in different directions. Hence it would follow, that in the usual mode of investigating this angle of complete polarisation by analysing the reflected light with the assistance of a doubly refractive crystal, we ought not, in any case, to lose sight of one of the images: that when we arrived, for instance, at the angle which causes all the red light of the mixed pencil to be polarised, and to pass into the ordinary pencil, the observer ought to see an extraordinary image formed of the *white wanting the red*, that is, *green;* and the same for the other colours. Notwithstanding this, it has been added, in the greater number of cases, the crystal being properly arranged, one of the images is weakened by little and little, as we approach to the appropriate inclination, and at last disappears entirely without presenting any visible traces of colour.

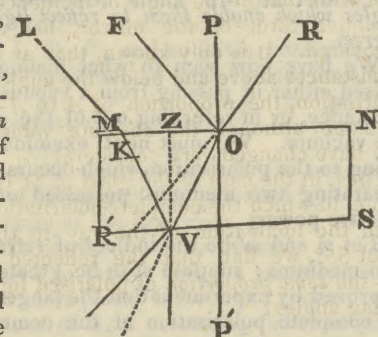
It may be answered, in the first place, that there actually are substances in which this appearance of colour *is* manifest: and which, therefore, do *not* polarise the rays of different kinds at the same angle, but accord with the law of the tangent. Among others may be adduced the instance of specular iron ore, in which the phenomenon is very striking; and the oil of cassia, of which the great dispersive power renders it also perfectly distinct. It may be added, too, that there is every reason to hope, that more accurate observations made with homogeneous light from different parts of the spectrum, and more precise measurements of the quantities of light that escape polarisation, at inclinations approaching to that of complete polarisation, will hereafter remove the slight appearance of disagreement between experiments and a law too nearly approaching to the whole mass of the phenomena, to be considered as otherwise than rigorously accurate.

The table already inserted contains the names of several mediums, such as the diamond, and sulfur, which do not completely polarise light: the law of the tangent *seems* therefore applicable to such mediums as these, provided that we understand, by the angle of polarisation, that in which the reflected pencil contains the greatest proportion of polarised light. In this case, the observation of this angle for metals would be the more important, as their refractive density has not been hitherto determined.

The angles of greatest polarisation, measured from the perpendicular, appear to be, for mercury $76\frac{1}{2}°$; for steel, above 71°: hence the index of refraction for mercury and for steel ought to be 4.16 and 2.85. [The oxid colouring the surface of heated steel has been found to give about 2.1 for its index, which agrees sufficiently well with this experiment.]

We have hitherto only spoken of the polarisation which takes place at the first surface of transparent surfaces, entered by the light; the second surfaces possess analogous properties with respect to light passing out of them.

The angle, measured from the perpendicular, at which light is polarised when it is on its passage from a vacuum into a refractive medium, is greater than that in which the same phenomenon is observed when the light coming from the medium tends to pass into the vacuum; it is also shown by experiment that the *sine of the former angle is to the sine of the latter* as the index of refraction is to unity. We might express the same fact by saying that at the second surface, as well as at the first, *the ray completely polarised* by reflection is perpendicular to the refracted ray. It follows, also, that if a medium is contained between two parallel surfaces, and if we throw a pencil of rays on the first surface, in the angle which affords complete polarisation, the transmitted portion of the pencil will also fall on the second surface in the angle which again produces complete polarisation.



Thus, if MN, RS, be the parallel surfaces, OR the incident ray; n the index of refraction; and OV the refracted ray; the angle of refraction VOP′ will always be equal to the angle OVZ, formed by the refracted ray with VZ the perpendicular to the second surface. Now, according to the assigned law, when POR is the angle of complete polarisation for the first surface, $\sin POR$: sin angle of polarisation at the second surface $= n : 1$, whence $\sin POR = n$ sin angle of polarisation at the second surface. But from the law of the sines, as in the other cases, we have $\sin POR : \sin VOP' = n : 1$, therefore $\sin POR = n \sin VOP' = n \sin ZVO$; an equation which, combined with the former, gives the angle of complete polarisation at the second surface $= ZVO$.

Hence it follows that if the incident ray, being previously polarised, is such as to escape all partial reflection at its entrance into a substance terminated by parallel surfaces, it will also escape reflection upon its passage out of the substance.

If ROP has the appropriate value, OF becomes completely polarised, and VK likewise; the subsequent refraction in K makes no alteration in this ray: so that when we wish to procure polarised light by reflection from a transparent plate, there is no occasion to blacken the second surface of the plate, supposing it parallel to the first, the polarisation will be equally complete, and the reflected pencil will be brighter. It will only be proper to take care, by placing at a distance from the plate a black substance, as a piece of velvet, for example, to intercept the rays

which might be transmitted by the plate from other objects beyond it.

The law from which these consequences have been deduced is only a particular case of a more general law, which may be thus enunciated.

The sine of the angle at which a pencil must be reflected at the first surface of a refractive medium, in order that it may contain a certain PROPORTION *of polarised light, is to the sine of the angle at which a reflection at the second face only would cause an* EQUIVALENT POLARISATION *in the same pencil, as the sine of incidence to the sine of refraction.*

It has been found by experiment, that the sine of the angle, at which a certain proportion of a natural pencil is reflected at the first surface of a transparent substance, is to the sine of the angle at which an equal proportion of the same pencil would be reflected at the second surface, if it arrived there immediately, as the sine of incidence to the sine of refraction. This law of photometry, combined with the former, leads to a very simple enunciation.

The first and second surface of a transparent substance polarise light in an equal degree, at the same angles which enable them to reflect light in an equal degree.

We have now seen in what manner light is polarised either in passing from a vacuum into a given substance, or in returning out of the substance into the vacuum. We must next examine the laws relating to the polarisation which occurs at the surface separating two mediums possessed of unequal refractive powers.

Let m and m' be the indices of refraction for the two mediums: suppose m to be greater than m': it is proved by experiment that the tangent of the angle of complete polarisation at the common surface is equal to $\frac{m}{m'}$, [which in fact is the index of refraction for that surface.]

Hence it follows that the reflected and refracted rays are perpendicular to each other, as in other cases of complete polarisation.

SECT. V.—*Of* REFRACTION *considered as a Mode of Polarising Light.*

It was believed, for some time, that the rays of light were only polarised by transparent substances in the act of reflection, and that the refracted pencil always retained the properties of ordinary light. But this opinion was erroneous. It is true that the simple transmission of light through one or even two surfaces of any known substance is not sufficient for completely polarising a pencil of light; but at certain obliquities it occasions at least a partial polarisation; for in examining the rays transmitted obliquely by a plate of glass with parallel surfaces, by means of a crystal possessed of the property of double refraction, it is found that the two images differ sensibly in intensity.

Let A' be the part of the transmitted pencil which is polarised, B' the portion of the same pencil not so modified; and A and B the analogous portions of the pencil reflected at the same incidence.

We have already said that A is polarised as an ordinary ray would be, transmitted by a crystal having its principal section coinciding with the plane of reflection; the poles of A', on the contrary, are placed like those of the extraordinary ray of the same crystal. If we analyse with a rhomboid the light reflected by a plate of glass, we find, for example, when in a certain position of the principal section, the image on the right hand is the more brilliant: and the relative position of the plate, the crystal, and the eye, remaining unaltered, it will be the opposite image, on the left hand, that will become the most conspicuous when we examine the transmitted light. All these results may be thus enumerated.

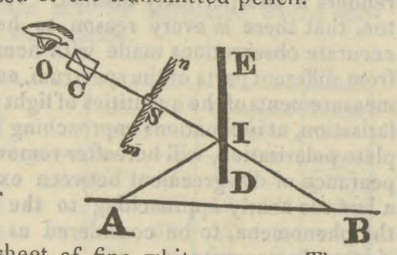
The plane which contains the poles of the transmitted light is perpendicular to that which contains the poles of the reflected light.

These different pencils are therefore polarised in directions at right angles to each other.

If we submit the reflected light $A+B$ to the action of a crystal of carbonate of lime, of which the principal section coincides with the plane of reflection, the intensities of the ordinary and extraordinary pencil will become $A+\frac{1}{2}B$ and $\frac{1}{2}B$.

In the same position of the plate and of the crystal, the intensities of the same images, furnished by the transmitted pencil, will be $\frac{1}{2}B'$ and $A'+\frac{1}{2}B'$.

A will therefore be the quantity by which the *ordinary* image, furnished by the reflected pencil, *surpasses* the extraordinary image, while A' will express, for the transmitted pencil, the quantity by which the *extraordinary* image will surpass the ordinary. With respect to this phenomenon, a remarkable result of experiment may here be noticed: that is, that in every possible inclination $A=A'$, or, in other terms, that the intensities of the two images afforded by the crystal differ in the same degree, whether we consider the reflected or the transmitted pencil.



Let us suppose that a plate of glass ED is placed in the position that the figure represents, before a medium AB of a uniform tint, for instance a sheet of fine white paper. The eye placed at O will receive simultaneously the ray IO, reflected at I, and the ray BIO transmitted at the same point. Place at mn an opaque diaphragm, blackened, and perforated by a small hole at S. Lastly, let the eye be furnished with a doubly refracting crystal, C, which affords two images of the aperture.

If now, by means of a little black screen, placed between B and I, we stop the ray BI, which would have been transmitted, the crystal, properly placed, will give an ordinary image $=A+\frac{1}{2}B$, and an extraordinary image $=\frac{1}{2}B$. But if the screen were placed between A and I, and the ray AI were intercepted, we should still have two images of the hole, and their intensities would be $\frac{1}{2}B'$ and $A'+\frac{1}{2}B'$ respectively. Consequently, without any screen, if the whole of the reflected light AIO and the transmitted BIO are al-

Polarisation of Light.

lowed to arrive at the eye, we shall have for the ordinary image, $A+\frac{1}{2}B+\frac{1}{2}B'$, and for the extraordinary, $\frac{1}{2}B+A'+\frac{1}{2}B'$.

Now it appears, from actually making the experiment, that the two images are perfectly equal, whatever may be the angle formed by the ray AI with the plate of glass, which can only be because A is always equal to A'. Consequently,

The quantity of polarised light contained in the pencil transmitted by a transparent plate, is exactly equal to the quantity of light polarised at right angles, which is found in the pencil reflected by the same plate.

Hence it follows, that at the angle of complete polarisation by reflection, the two images of the transmitted pencil given by a crystal properly placed, differ in intensity by a quantity equal to the whole of the reflected pencil. So that if ever a body should be discovered, that could reflect half of the light incident at this angle, the pencil transmitted, at the same inclination, would also be completely polarised.

In order to simplify this reasoning, we have supposed throughout that there was only one efficient surface in the plate ED; it would be entering into too much detail if we proceeded to demonstrate in what manner this supposition might be justified: and it will be sufficient to remark, that the experiment in question succeeds equally well when ED is a simple plate of glass with parallel surfaces, which implies that the second surface polarises also equal quantities of light by reflection and by refraction. But, lastly, in order to remove every doubt respecting the accuracy of these results, it may be added, that when some natural light, and some light that had passed through a rhomboid of carbonate of lime was thrown on a plate of glass reflecting at one of its surfaces, or at both, it was found that the reflected light contained the same quantity of polarised rays in both cases. Now the reflecting plate exercises no particular action on the two equal pencils of light transmitted by the rhomboid, and polarised in directions perpendicular to each other; it only divides them unequally: and if the reflected pencil contains an excess of rays polarised in one direction, there will be found in the transmitted pencil an excess precisely equal of rays polarised in the direction perpendicular to it. In this case, the law here laid down must necessarily be true: and in order to extend it to natural light, it is sufficient to have assured ourselves, as we have done, that it is affected in the act of reflection and in that of refraction precisely in the same manner as the combination of two equal pencils, polarised at right angles to each other.

One of the best modes of verifying the accuracy of physical laws is, to inquire what their results are in extreme cases. The law now in question, supposing it universally true, leads us, for example, to this conclusion, that where there is no transmission of light, there can be no polarisation: and in fact, if we cause a pencil of light to fall on the interior surface of a prism, at an inclination which produces complete reflection, we shall find no trace of polarisation in the reflected pencil, although at incidences but little different, a considerable part of the light, and even the whole may have been polarised.

Let us represent by A the part of the pencil I which is polarised by reflection, at the angle of 35° from the two surfaces of a plate of glass; the pencil transmitted will be $I-A$; now in this quantity of light there will be, according to the law laid down, A rays of which the plane of polarisation is perpendicular to that of the reflected rays, so that the quantity of natural light remaining will be $I-2A$, which we may call $=I'$. Then the pencil $I'+A$ falling on a second plate, parallel to the first, and consequently at the same angle as before, A will entirely escape the partial reflection, and abating what may be lost by absorption, will be found entire in the pencil transmitted by the second plate; I' will be divided in the same manner as I was at first; a portion A' of I' is polarised by reflection, the remaining portion $I'-A'$ is transmitted, and will contain A' of polarised rays, so that the natural light, after passing through the second plate, will be reduced to $I'-2A'$, and the quantity polarised by refraction will be $A+A'$. Making $I'-2A'=I''$, the light $I''+A+A''$ will furnish, in its passage through a third plate, parallel to the two former, a new quantity A'' of light polarised by refraction, which will be added to $A+A'$, and so forth.

The pencils I, I', I'', and so forth, consisting of natural light, are polarised in equal *proportions*, by the respective plates: the quotients $\frac{A}{I}, \frac{A'}{I'}, \frac{A''}{I''}$, will constantly have the same value. If, for instance, one sixth part of the pencil I is polarised by reflection at the surfaces of the first plate, $\frac{1}{6}$ of I' will be polarised at the surfaces of the second; $\frac{1}{6}$ of I'' by the third, and so forth; and the pencils transmitted by these same plates will contain respectively of natural light, or of light possessing the same properties, $\frac{4}{6}$ of I, $\frac{4}{6}$ of I', $\frac{4}{6}$ of I'', and so forth. Hence, whatever may be the number of plates employed, the pencil ultimately transmitted will contain, mathematically speaking, a certain quantity of natural light; but this quantity will be rapidly diminished, and will finally become completely insensible. [Dr Brewster, on the contrary, maintains, that it wholly disappears after transmission through a finite, and even a moderate number of plates.]

It may be said, in this sense, that a pile of parallel plates polarises the light which passes through them, in a direction perpendicular to the plane in which the rays would be polarised, by reflection at the same surfaces.

We have here supposed the incident light to meet the plate of glass at the inclination capable of polarising it completely by reflection; but the same result is obtained whatever the inclination may be: it is only necessary that it should be composed of a number of elements, so much the greater as the direction of the rays is nearer to the perpendicular.

With a given inclination, the number of plates, necessary to produce by transmission a polarisation nearly complete, depends also on their reflective power: we have already observed, for example, that a single plate, capable of reflecting half the incident light at the angle of polarisation, would, of itself, be sufficient to constitute a pile.

There are certain natural bodies, the agate, for example, which modify the transmitted light precisely as a pile of plates would do. If we cut a plate of agate sufficiently thick, in a direction perpendicular to that of its laminae, the light which passes through it acquires a polarity in the direction of the plates. A similar property is observed in the tourmaline, and it is here the more remarkable, as this mineral, when pure, exhibits no lamellar structure whatever. If the two opposite faces of a prism of tourmaline are polished so as to form it into a plate with parallel surfaces, about $\frac{1}{25}$ of an inch in thickness, the light transmitted by it, whatever its angle of incidence may be, will be polarised in a direction perpendicular to the axis of the column.

It will be proper to mention here the phenomena exhibited by piles of plates when they are exposed to rays that have been previously polarised: supposing always that the pile is formed of parallel plates of glass; and besides, that the angle of inclination to the first surface is about 35°, reckoning from the surface itself.

If the primitive plane of polarisation of the incident ray coincides with the plane drawn through this ray and the perpendicular to the first plate at the point of incidence, a part of this ray more considerable than if we employed natural light, will be reflected; at the point of incidence on the second plate, the luminous pencil transmitted by the first will undergo reflection in the same proportion as the former pencil: the same effect will take place in the third plate and so forth. The transmitted ray, however intense it may have been in the first instance, will thus be gradually weakened in a geometrical progression, and at last will become insensible; so that if we look at the pile on the opposite end it will appear to be an opaque body, perfectly impervious to light.

Every thing else remaining in the same state, if we turn the pile round the ray as an axis through an angle of 90°; the new plane of reflection will be perpendicular to the former, and the plate will have reached the situation which has been already mentioned, in which the reflective property wholly disappears, and the whole of the light will pass through it. But the second plate, the third, and all the following plates, which are parallel to the first, will be found in the same circumstances possessing the same properties, and will not reflect any of the incident light; so that setting aside the effect of absorption, the apparatus actually transmits light without weakening it.

The pile of plates possesses therefore, with respect to polarised light, the singular property of being either completely opaque or perfectly transparent according to the side which it presents to the light, notwithstanding that the inclination of the light to the first surface remains constantly 35°. In the intermediate positions the quantity of transmitted light increases gradually as we proceed from that in which nothing is transmitted, to the other extreme in which the light is only weakened by absorption.

Tourmalines and agates appear to be true piles of plates, so that they must produce similar effects: and in fact, a plate cut, for example, in a direction parallel to the axis of a column of tourmaline transmits rays which are polarised in a plane perpendicular to the axis, and totally stops, on the other hand, rays of which the primitive plane of polarisation is parallel to that axis.

When we place such a plate between the eye and a reflecting surface of water or glass situated in the open air, and look at it with an inclination producing complete polarisation, it appears either fully enlightened or quite dark, or in intermediate states according to the situation of the plate in its own plane. A circumstance, which adds to the singularity of this experiment, is that it succeeds completely even when the incidence on the plate is perpendicular; while for a pile properly so called, unless it be composed of an immense number of plates, it is necessary that the distance of the ray from the perpendicular should be very considerable.

Whatever may be the cause of these phenomena, it results evidently from what has been mentioned, that two planes of tourmaline placed so that their axes form a right angle, must compose a system perfectly opaque with respect to light of all kinds. If, for example, the incident light is in its natural state, it is obvious that the portion transmitted will be polarised in the direction of the axis of the plate, and that the second plate, situated in a perpendicular direction will consequently stop the whole of the light so polarised.

SECT. VI.—*Of the* DEPOLARISATION *of Light.*

After having examined in what manner ordinary light is converted into polarised light, we must now proceed to study the modifications which this latter undergoes in its turn when it is subjected to reflection or refraction at surfaces of different natures, and differently situated with respect to its poles.

When a polarised pencil falls on the surface of a well polished mirror, in such a manner that its plane of polarisation coincides with the plane of reflection, or is perpendicular to it, the light regularly reflected at this surface is completely polarised, like the incident pencil, in a direction parallel or perpendicular to the plane of reflection; and this happens whatever the nature of the mirror may be.

But whenever the primitive plane of polarisation of the incident pencil is any otherwise situated, it will be found that the reflected pencil is modified, and the modification will depend on the nature of the mirror.

When we employ for these experiments a mirror either transparent or opaque, which is capable of *completely polarising natural light;* the rays previously polarised which fall on this surface will *again be completely polarised* after their reflection; but *not in the plane of their primitive polarisation.* This *deviation* of the plane of polarisation of a luminous pencil, produced by its reflection at the first surface of a transparent mirror, depends both on the angle of incidence and on the direction of the plane of reflection with regard to the poles of the ray.

For given inclination, the deviation is so much more considerable as the plane of reflection makes with the plane of primitive polarisation an angle more nearly approaching to 45°.

Let us first suppose, in order to assist the imagination, that the reflecting surface is horizontal; that the eye of the observer, and the rhomboid which is to furnish the polarised pencil remain constantly situated the one to the north, the other to the south of the point of reflection, so that the plane of reflection may always coincide with the meridian: and that lastly the principal section of the crystal, which contains in its plane the poles of the ordinary pencil, makes an angle of 45° with the meridian.

When this ordinary pencil falls perpendicularly on the mirror, it will be reflected without any deviation of its plane of polarisation: so that this plane, having at first formed, by the suppositions, an angle of 45° with the meridian, the inclination to the meridian will remain the same after the reflection.

If we cause the direction of the incident light to vary more and more from the perpendicular, we shall first remark that the plane of polarisation of the reflected light approaches by degrees to the plane of reflection; and that it coincides exactly with it when we have arrived at the angle of complete polarisation; that afterwards the reflected ray is polarised in a plane which is more remote from the plane of reflection in proportion as it forms a smaller angle with the surface of the mirror; and that at last when the ray is nearly parallel to the surface, its plane of polarisation coincides with that of the incident light, as it did when the incidence was perpendicular.

Let us call the angle of incidence, reckoned from the perpendicular, i, the corresponding angle of refraction for the substance concerned, i': the tangent of the angle, formed by the plane of polarisation of the reflected light with the plane of reflection, will be expressed by $\frac{\cos(i+i')}{\cos(i-i')}$.

This formula may be illustrated by applying it to particular cases. If $i=0$, i' being also $=0$, $\frac{\cos(i+i')}{\cos(i-i')}=1$: but the angle of which the tangent is unity is an angle of 45°. Consequently, if the formula is correct, the plane of polarisation for the reflected ray, when the incidence is perpendicular, must coincide with the primitive plane of polarisation of the light employed; and this is conformable to observation.

The angle of which the tangent is $\frac{\cos(i+i')}{\cos(i-i')}$ becomes also 45° when $i=90°$: that is to say, when the rays are parallel to the surface concerned, since then $\cos(i+i')=-\cos i'$, and $\cos(i-i')=+\cos i'$. The light preserves, therefore, in this case also, its primitive plane of polarisation, as the experiment had shown.

If $i+i'=90°$ the angle i, as it has already been observed, (Sect. III.) is that of complete polarisation, and $\frac{\cos(i+i')}{\cos(i-i)}$ is $=0$: so that the plane of polarisation of the reflected ray coincides with the plane of reflection; which has already been shown by experiment.

The following table will show that, for intermediate angles of incidence, the agreement between this mode of calculation and the observation is as satisfactory as it was possible to expect.

On Glass.

Angles of Incidence.	Observed Deviation of the Plane of Polarisation.	Computed Deviation.	Difference.
24°	38° 55′	37° 54′	+1° 1′
39	24 35	24 38	—0 3
49	11 45	10 52	+0 53
56½	0 0	0 0	0 0
60	5 15	5 29	—0 14
70	19 52	20 24	—0 32
80	32 45	33 25	—0 40
85	38 55	39 19	—0 24
87	40 55	41 36	—0 41
88	41 15	42 44	—1 29
89	44 35	43 52	+0 43

On Water.

Angle of Incidence.	Observed Deviation.	Computed Deviation.	Difference.
53°	0° 0′	0° 0′	0° 0′
60	10 20	10 51	—0 31
70	25 20	24 48	—0 32
80	36 20	35 49	+0 31
85	40 50	40 32	+0 18

The formula, thus compared with experiment, supposes, that the primitive plane of polarisation of the light employed *makes an angle of 45° with the plane of reflection*: but a slight addition is sufficient to accommodate it to all other cases. If we make a the angle of which the particular value is here assumed 45°, i and i' retaining their values, the tangent of the angle expressing the deviation of the plane of polarisation of the incident pencil, after reflection, will in general be represented by $\frac{\cos(i+i')}{\cos(i+i')}$ tang a.

It is easy to observe, that in the most material cases, this formula correctly corresponds with the experiments: but we are still in want of an experimental demonstration of its truth for any very diversified combinations of the values of a and i.

The deviations of the planes of polarisation follow the same gradations when the reflection takes place at the second surface of transparent mirrors, from the position of perpendicular incidence to that of the beginning of total reflection. But beyond that inclination, the phenomenon acquires a character totally different: we have then no longer a simple change of the direction of the primitive poles of the ray; for unless the plane which contains the poles either coincide with the plane of reflection or be perpendicular to it, the ray will undergo a true depolarisation, so that however we place the rhomboid through which we cause it to pass, we shall always

observe, that two images are formed. The same happens also when the mirror is metallic: The particular and very remarkable modifications which the light undergoes in these two cases will shortly be mentioned.

Sect. VII.—*Of the Phenomena of* INTERFERENCE, *so far as they are modified by a previous Polarisation of Light.*

It has long been known, [having, however, first occurred to the translator of this article in the room and at the table on which he is now writing,] that if, after having cut in a thin plate of metal, two very fine slits very near to each other, we cause them to be enlightened by a pencil proceeding from the same radiating point, we may observe behind the plate a formation of iridescent fringes, derived from the action exerted by the rays scattered from the left hand slit on the rays scattered from the right hand slit, in the points where these two parcels of rays are intermixed.

This experiment, when studied in all its details, has led to the simple law, which may be thus enunciated: Two rays of homogeneous light, *proceeding from the same source*, and arriving from a given point of space by two different routes, a little unequal in length, co-operate with each other, or are destroyed, and form, on a screen which receives them, either a bright or a dark spot, according to the magnitude of the difference of their routes.

The two rays always co-operate completely, when they are united after passing through a route of equal length. If the smallest difference of routes, which will cause them again to co-operate, be called d, they will co-operate wherever the distance is any member of the series $2d$, $3d$, $4d$... ; and the intermediate values $0+\frac{1}{2}d$, $d+\frac{1}{2}d$, $2d+\frac{1}{2}d$..., will show the cases in which the two rays, when combined, produce darkness. The magnitude of the quantity d varies with the species of light concerned, and with the nature of the medium which transmits it.

If two rays destroy each other after having passed through routes differing, for example, by the quantity d', they will also destroy each other after having passed through, either perpendicularly, or with the same obliquity, two plates of *the same nature, and of the same thickness.*

A difference of thickness or of refractive density, in the two plates interposed, may produce the effect of an inequality in the routes described: the difference will give rise, in certain cases, to a displacement only of the fringes: but in others they will entirely disappear.

These laws relate to the rays of light in their natural state; if we employ polarised light, we obtain results, which, independently of the numerous applications of which they are susceptible, deserve for their singularity to arrest our attention.

Let us first suppose that instead of enlightening *the two* slits of the plate of metal with natural rays, we employ polarised light, the fringes will be formed equally in both cases.

If we then try the effect of the light polarised in one direction and transmitted by one of the slits on the light polarised in a perpendicular direction, and transmitted by the other; an arrangement which may be obtained by placing two piles properly directed in the passage of the different rays: we shall find that when the directions are correctly perpendicular, there is no trace of fringes behind the perforated plate.

It has been remarked that any material difference in the mediums through which the two rays pass, is sufficient to annihilate the effects of interference which would otherwise be observable. The experiment now mentioned would therefore be wholly inconclusive, if we had not previously assured ourselves that the piles, which are supposed to be of the same nature, are also exactly of the same thickness. The best mode of ascertaining this is evidently to render the two planes of polarisation parallel: if in this case we perceive fringes, and if after having turned one of the piles one fourth of a revolution round its axis without changing their mutual inclination, we find that they disappear, we may fairly conclude that this disappearance must be attributed to the direction of the polarisation of the rays of light concerned.

This experiment would be a very difficult one to make with success if the piles had any considerable thickness: but they may be made very thin by means of plates of mica, or of bits of glass blown in a lamp: and then by dividing them in the middle, we may obtain a pair of piles of thicknesses perfectly equal. Besides, nothing prevents our varying gradually the inclination of one of the piles, so as to compensate in this manner for the effect of a slight difference of thickness, if it exists.

But there is another mode of observation which is more convenient. We take a crystal of tourmaline cut in a direction parallel to its axis, so as to form a plate with parallel surfaces; we divide it into two parts, and apply the two portions, one to the slit on the right hand of the plate, and the other to that on the left. We then find that fringes are produced when the two axes of the fragments are parallel; and that no traces of them are left when they are perpendicular to each other; and that in changing the positions of the portions of tourmaline from one of these relations to the other, the intensity of the fringes gradually disappear.

Supposing now the piles to remain fixed to the slits in perpendicular directions, so that no fringe may be visible; and placing a third pile before the eye of the observer, in a plane that forms an angle of 45° with the planes of incidence of the two former: this last plane must reduce to a similar polarisation the rays coming from the two slits, which before they met were polarised at right angles; so that there seems to be no reason why the rays should not again interfere: and yet whatever pains we take in the experiment, we shall discover no trace of fringes. [Might there not, however, be fringes if the rays met behind the third pile rather than before it? Tr.]

It is unnecessary to remark, that a tourmaline of any kind may be substituted for the third pile, as the two former may be exchanged for the two halves of a piece of tourmaline with parallel surfaces: the result will be precisely the same.

Let us lastly suppose, in order to exhaust all possible combinations, that the plate of metal is illuminated with polarised light, and that two piles or two tourmalines are so placed, as to transform the rays passing through the two slits from rays polarised in the same direction, into rays polarised in directions at right angles to each other: and that before the interference of the rays we bring them back to a similar polarisation, either by the assistance of a third pile, or by that of a tourmaline, as in the former experiment: the observer will then find, and, no doubt, with great surprise, that the rays are again susceptible of interference; or that in mixing together they produce a very visible group of iridescent fringes.

The series of experiments here related leads us to the following conclusions.

1. Two pencils converted from natural light into light polarised in the same direction, retain, after this modification, the property of interfering with each other.

2. Two pencils, which are made to pass directly from the state of natural light to that of light polarised in two perpendicular directions, are no longer capable of interference, either while they remain in this state, or after they have been restored to a similar polarisation.

3. Two pencils polarised in contrary directions, do not interfere, whatever may have been the modifications that they have undergone before they arrive at this state from that of natural light: but when restored to a similar state of polarisation, they become capable of interfering, provided that in their passage from the natural state to that of polarised light THE FIRST planes of polarisation of the two pencils were parallel.

Thus it appears that in these phenomena the mode of action of the rays does not depend on *what they are* only when they meet, but also *on what they have previously been*.

SECT. VIII.—*Of the kind of Polarisation which is exhibited in the appearance of Colours, and which has therefore been called* COLOURED POLARISATION.

We may first examine the *nature* of the new modification of light that is concerned in these appearances; and secondly, the *means* of producing it.

Supposing a ray of direct light to be polarised in any of the ways that have been described, and then to pass through a plate of rock crystal, cut perpendicularly to the edges of the hexaedral prism, about a quarter of an inch in thickness, and having both its surfaces perpendicular to the ray: when it emerges from the surface, it will no longer possess the properties of common polarised light; and yet it will not have reassumed the characters of direct light: for if we submit it to the action of a rhomboid of carbonate of lime, instead of affording one image only in a particular position with respect to the principal section of the crystal, it will be *constantly* subdivided into two pencils: so that it cannot be identical with common polarised light.

Neither is it simply natural light: for a white pencil of natural light is always divided by a doubly refracting crystal, into two white pencils of equal intensity: the white pencil which has passed through the plate of quartz, on the contrary, gives always two images, but they are distinguished by the most vivid colours. If the ordinary image is red, the extraordinary is green, and the reverse; and the case is the same with regard to the other prismatic colours; that of the ordinary pencil is complementary to the tint of the extraordinary pencil, and they both vary according to the position of the principal section of the rhomboid which causes the separation.

The prismatic telescope of Mr Rochon affords an apparatus perfectly adapted to the performance of these experiments, and which requires to be mentioned first, because it exhibits the tints with great brilliancy; secondly, because it gives us the means of assuring ourselves, that the images viewed lose nothing of their distinctness by the interposition of the plate, and that its effect is not owing to any irregular dissipation of the light concerned; and thirdly, on account of the facility with which it allows us to show that the tints are complementary to each other.

This instrument is nothing more than an ordinary telescope, furnished, between the object glass and the eye glass, with a prism of rock crystal or of carbonate of lime, rendered achromatic. This prism being moveable at pleasure along the axis of the telescope, the observer is enabled to separate more or less, at his pleasure, the two images of the object which he is viewing.

Having then before the object glass of this telescope the plate of quartz in question, and adapting besides to the eye glass a greenish dark glass of a particular kind, which is much employed by astronomers because of its property of absorbing a good deal of light, without sensibly colouring the transmitted pencil: if we observe the sun directly with this instrument, we shall see two images of the sun, both white, and of equal brightness; whence it follows that the plate produces no particular effect on natural light: but if on the contrary we look at the sun's image as reflected by a plate of glass not silvered, we shall perceive two more suns, each of them coloured; and while the telescope performs half a revolution on its axis, they will both run through nearly the whole series of the prismatic colours. Thus, the image, that was red, will become successively orange, yellow, greenish yellow, bluish green, and violet: and at this period the telescope will have made half a turn; its movement being continued, the violet image will become first red, then orange, and so forth. The second image will always give us the complementary colour: for if, instead of completely separating the images, we allow them to overlap each other, the part common to both the discs will remain constantly white: while the remaining lunular portions will exhibit the most vivid colours.

The reflection of a transparent plate may also be employed for more directly exhibiting the distinctive properties of the light transmitted by the plate of quartz.

If we cause a plate of glass to turn round a pencil of natural light forming with its surface an angle of about $35\frac{1}{2}°$; the reflected pencil will be directed in succession to all the points of the horizon, but it will constantly preserve *the same intensity*.

But if the incident pencil is polarised, we shall find, on the contrary, two positions diametrically opposite to each other, in which the mirror will not reflect *a single ray*.

Making, now, a similar experiment with the light that has been transmitted by a plate of rock crystal, we shall see that it becomes coloured by reflection, though it falls white on the plate, and that the nature of the *colour* depends on *the side of the ray* that is presented to the reflecting surface. These reflected colours succeed each other during the revolution of the plate, in the same order as in the prismatic spectrum: they are also observed in the transmitted light, being always complementary to those of the light reflected at the same time.

If the properties of polarised rays depend, as is supposed by the partisans of the system of emission, on the particular arrangements assumed by the molecules of which they are formed, it will be easy to describe the intimate composition of the ordinary polarised ray; and that of the same ray after it has passed through the plate of rock crystal: in the former, the axes of all the molecules of the different colours, must be parallel; in the latter, the molecules of different tints must have their poles turned towards different parts of space.

It now becomes necessary to examine according to what law the direction of these poles is varied, both as they depend on the particular tint of each molecule, and on the greater or less thickness of the crystal that they have passed through.

If we employ homogeneous polarised light, we shall readily find, that, supposing a given plate of quartz to turn the poles of a certain ray of light through an arc of 20° from their primitive direction, a plate of the same crystal twice as thick will cause a double deviation, and will turn the pole through an arc of 40°; a plate of thrice the thickness will cause a triple deviation, amounting to 60°, and so forth without limit.

With regard to the simple rays of different colours, in passing through a given plate, they undergo deviations so much the more considerable as they are more refrangible, and this in the inverse proportion of the numbers which Newton calls the lengths of the fits; or, what comes to the same result, in the inverse proportion of the quantities which have been designated in this article by the letter *d*. (Sect. VII.)

When, therefore, we know the deviation for a given plate, we may find the effect of a thicker or thinner plate of the same substance by a simple proportion.

Table of the Deviations of the Planes of Polarisation of the different "Homogeneous" Rays in passing through a Plate of Rock Crystal perpendicular to the Axis of the Prism, of which the thickness is a millimetre, or .03937 E. I.; [according to the Newtonian division of the spectrum.]

Extreme red	17.50°
Limit of red and orange	20.48
orange and yellow	22.31
yellow and green	25.68
green and blue	30.05
blue and indigo	34.57
indigo and violet	37.68
Extreme violet	44.08

There is no reason to suppose that the angular deviations will undergo any alteration in their values when all the molecules pass through the crystal at the same time. Consequently, in the white pencil transmitted by a plate of a millimetre, the axes of the elementary red rays will form an angle of 8° with the axes of the first orange rays; of about 5° with those of the first yellow rays, and of 26.5° with the axes of the extreme violet rays: and if we analyse this white pencil by means of a rhomboid, the differently coloured rays will not be divided in the same proportions between the two images: hence there will necessarily be appearances of colour. It is obvious, for example, that when the rhomboid is so placed that its principal section shall coincide with the poles of the red ray, this ray will remain altogether in the ordinary pencil, and the red tint will be wholly wanting in the extraordinary image.

We may obtain an exact idea of the modification which a plate of quartz produces in a white pencil of polarised light, by conceiving a combination of red rays polarised by reflection at the surface of a certain transparent substance, of orange rays polarised by a second surface placed in a different angular situation, of yellow rays polarised by a third surface, and so forth. The necessity of the intimate mixture of all these kinds of molecules in each line of white light, and some other obstacles, would render it impossible to realise this fiction without a very complicated apparatus: while a simple plate of quartz is sufficient, on the other hand, to give to the different constituent parts of the white pencil these individual polarisations situated in different azimuths.

The phenomena which have been described are produced by plates of quartz with parallel surfaces cut perpendicularly to the axis of the hexaedral prism. Now in a direction perpendicular to these surfaces quartz exhibits no double refraction: so that the causes, which in this case produce the deviation of the planes of polarisation of the luminous molecules, are different from the causes which occasion the separation of the two pencils in other sections of the crystal. And it is remarkable that the properties of these plates have been found in bodies not possessed of regular crystallization, as flint glass, and even in perfect fluids, such as the essential oils of turpentine and of lemons, or the solution of camphor in alcohol, the simple syrup of sugar, and so forth. The only difference is in the absolute value of the thicknesses which afford the same tints: the other laws remaining the same. Thus the thickness of oil of turpentine must be 69 times as great as that of a plate of rock crystal to produce the same effect: and the action of the oil of lemons is to that of the oil of turpentine as 17 to 10 [: or to that of crystal as 1 to 41].

We have seen that a plate of quartz a millimetre in thickness causes the poles of the red molecules to describe an arc of 17.5°. We may suppose this motion to have taken place from right to left: then every other plate, of whatever thickness, cut out of

the same crystal, will cause the poles to deviate still farther in the same direction, that is to turn still from right to left: while other plates, on the contrary, cut out of a different crystal, may turn them from left to right. This phenomenon, at first sight, must appear very singular; but if we reflect that the rays pass through the plates in a direction which affords no double refraction, we shall be aware that a deviation of the poles directed constantly the same way in every specimen of the crystal would be not at all less astonishing.

It has not hitherto been possible to point out any exterior signs which shall indicate the direction of the deviation that will be produced by a given crystal, except in one very remarkable case. In some varieties of quartz, the solid angles, situated at the base of the pyramid by which the prism is terminated, are replaced by as many facets placed obliquely with respect to the edges. Now the direction of the deviation, which these *plagiedral* crystals give to the poles of the luminous molecules, is constantly that of the obliquity of these little facets.

When a polarised ray passes successively through two plates producing contrary rotations, the ultimate deviation of the poles is the difference of the effects which each plate would have produced separately. The ray exhibits exactly the same tints as if it had passed through a single plate, of a thickness equal to the difference of the thicknesses of the two plates.

If the plates thus combined are equal in thickness, the pencil transmitted, having been turned first in one direction, and then turned back in the contrary direction, seems not to have its polarisation ultimately changed.

The essential oil of turpentine causes the axes of the molecules of the polarised ray to turn from the right to the left of the observer receiving the ray: the essential oil of lemons from left to right. These fluids do not lose their peculiar properties, when they are mixed; so that if their proportions in the mixture are inversely as their rotatory forces, the ray which has passed through them retains its primitive polarisation.

Sect. IX.—*On the Phenomena of* DEPOLARISATION, *and of* COLOURS *produced by* CRYSTALLIZED PLATES *not cut perpendicularly to the Axis of Double Refraction.*

We are next to inquire how a white pencil, polarised in a single direction, is modified in passing through a crystalline plate possessed of double refraction.

For this purpose we may place the principal section of a rhomboid of calcarious spar in the plane of polarisation of a white pencil, which of course will be subjected to the ordinary refraction only: we may then place the plate in question before the rhomboid, so that the rays may pass through it perpendicularly. If now the principal section of this plate is parallel to that of the rhomboid, we shall still see but one white image; and the same will happen if the principal sections are perpendicular to each other: but in every other situation of the plate, the rhomboid will furnish two pencils, and they will be distinguished by *complementary tints*.

The motion of the plate in its own plane does not alter the *nature* of the tints: their brightness only varies, and becomes greatest when the angle formed by the two sections is equal to 45°.

These tints vary with the thickness of the plate, and degenerate into perfect whiteness when the thickness becomes considerable. In the sulphate of lime, the appearances are no longer observable when the thickness is about half a millimetre, or one fiftieth of an inch.

Supposing O to be the tint of the ordinary pencil, and E that of the extraordinary: the experiment shows that the tint E is nearly that of one of the coloured rings seen in the light reflected from two object glasses touching each other, as in the celebrated experiments of Newton; and that the tint O is that of the corresponding transmitted ring. This rule, however, is not perfectly general; for in many crystals the tints E by no means resemble those of the rings.

When the regular sequence of the Newtonian rings is observable, the successive thicknesses of the same crystal, which afford the respective colours E, are proportional to those which Newton has assigned for substances not crystallized: it is only found that, for any given density, the absolute values of these thicknesses greatly surpass the thicknesses shown in the Newtonian tables.

We find also a remarkable relation between the tint E, the thickness of the plate, and the elements of its double refraction, which it is important to point out. The image E only appears when the principal section of the plate is neither parallel nor perpendicular to the primitive plane of polarisation of the ray which passes through it. If we suppose this plate to possess only the ordinary properties of double refraction, the ray will in general be divided by it into two pencils, one of which will be refracted ordinarily, the other extraordinarily: so that two pencils from the same origin meet, after having passed through different routes, and *interfere*. There is a certain inequality of the lengths of these paths at which the red rays destroy each other; at another interval, the yellow rays, the green, the blue, and so forth. If we determine, from these principles, the tint resulting from the interference of the different rays, taking into account the thickness, and the intensity of the double refraction of the plate, we shall always find a very satisfactory agreement between the calculation and the experiment. [See the Article CHROMATICS, in this *Supplement*.]

The singular deviation which these thin plates seem to produce in the poles of the molecules of different colours which constitute while light, was extremely difficult to be discovered: and nothing shows this difficulty better than the general assent of natural philosophers to the laws which have been the foundation of the *theory of moveable polarisation*. It is not therefore sufficient to explain here the true principles on which these phenomena are founded: the confutation of an erroneous theory becomes absolutely necessary in this stage of the investigation;

especially when it is plausible in appearance, and when it is brought forwards with confidence in the latest works, notwithstanding the decisive objections which had been opposed to it.

The fundamental theorem of this *moveable polarisation* has been thus enunciated. "When a ray of natural light, polarised in a certain fixed direction, passes perpendicularly through a crystallized plate, which is parallel to the axis of double refraction, the molecules of light penetrate at first to a certain distance without losing their primitive polarisation: after this they begin to perform periodical oscillations round their own centres, so that their axis of polarisation is carried alternately on each side of the principal section of the crystal, or of the line perpendicular to it, like a pendulum passing from one side to the other of the vertical line which is its quiescent position. Each of these oscillations is performed in a given thickness $2e$, twice as great as that in which the molecule had made its excursion in one direction. *Thus, from the thickness zero to a certain fundamental thickness* e′ *the homogeneous molecules of which the ray passing through the crystal is composed, are affected, after their emergence, as if they had not quitted their primitive polarisation; from* e *to* 2e, *they are affected as if they had assumed a new polarisation, differing from the former by the azimuth* 2i; i *being the angle which the principal section of the plate forms with the original plane of their polarisation:* and they appear in short alternatively polarised in their former azimuth, and in an azimuth at the distance $2i$ from it."

To this law it may be objected, first, that whenever the light emerging from a crystal with one axis, whether thin or thick, is composed of two distinct pencils, we find that they are polarised in directions at right angles to each other, whether the incident light may have been natural or polarised: and no exception to this rule has yet been discovered. Now it is difficult if not impossible to conceive, in the system of moveable polarisation, how the transition can be made from that state into the state of polarisation in two directions at right angles, which, for the sake of distinction, has been called the fixed polarisation.

But there is a still more direct objection to this theory. If we place a plate of sulphate of lime in such a manner that its principal section may make an angle of 45° with the primitive plane of polarisation of homogeneous light that is to pass through it; the angle $2i$ being then equal to 90°, the transmitted pencil, according to the doctrine of moveable polarisation, *would be* ENTIRELY *polarised either in the primitive plane, or in the plane perpendicular to it,* and when analysed by means of a rhomboid, it would exhibit, in two positions of the principal section of this crystal, only a single image. But this is so far from being true, that *if the plate is of a proper thickness,* the pencil will be constantly divided into two images of equal intensities, whatever the direction of the principal section of the rhomboid may be.

When two pencils, derived from the same origin, and possessing the same velocity, are made to intersect each other at a very small angle, after having travelled by different paths, of which the lengths are slightly different, they may destroy each other completely, as we have already seen: and this destruction would as readily take place if they came by the same path with different velocities. Let d be the difference of the paths which determines, in the first case, the periodical series of the points of space in which two rays of a certain homogeneous light produce complete darkness by their interference: the same letter d will express, in the second case, the quantity by which one of the rays will require to be more advanced than the other by the excess of its velocity, in order that the light may again be destroyed. When, in a crystallized plate, the difference of the tracks described by the ordinary and extraordinary rays of a given kind of light, or when the effect of the difference of velocity is 0, nd, or $(n+\frac{1}{2})d$, n being a whole number, a pencil previously polarised, and transmitted by the plate, WILL APPEAR *entirely polarised in the primitive plane, or in the azimuth* 2i, as the principles of the doctrine of moveable polarisation require.

When the plate has such a thickness, that the difference of the paths described by the ordinary and extraordinary pencils is included in the general formula $(n+\frac{1}{4})\ d$, the *transmitted light will appear to have become common light,* if the principal section of the plate makes an angle of 45° with the primitive plane of polarisation of the incident light: which, as we have already seen, by no means agrees with the doctrine of moveable polarisation.

Lastly, when the thickness of the plate employed is not comprehended in any of the preceding expressions, *the completely polarised rays, which pass through it, emerge with the characters of a partial polarisation.* This result is no less inconsistent than the former with the laws of moveable polarisation; since, according to these laws, the polarised incident ray ought always to emerge completely polarised, with a simple change of the azimuth of its poles.

It is not, therefore, generally true, that a pencil of polarised homogeneous light, which passes through thin crystallized plates, either preserves its primitive polarisation, or assumes a new one at the angular distance of $2i$: and with this falls the whole fabric of the oscillatory motions attributed to the molecules of light. With respect to the objection already made to this theory, regarding the connexion to be established between the phenomena of thin plates and those of thick crystals, it seems to retain its full force, since it has not been established by experiment that the rays concerned in the phenomena of thin plates are polarised in two rectangular directions.

Supposing, however, for a moment, that this were the case, and that a luminous pencil, passing through a thin plate of sulphate of lime, is divided into two rays, the one ordinary and the other extraordinary, polarised at right angles: let us examine what would be the consequence. Mathematically speaking, these two rays follow in general different routes within the crystal; but it is not possible to separate them physically, because the imperfection of our organs forces us to contemplate objects of a certain extent. The advocates of a moveable polarisation will examine this light *in a mass.* They will find in certain cases that it appears to have preserved its primitive polari-

sation; and in others that it seems to be polarised in an azimuth differing by $2i$; and they will hence conclude that thin plates act very differently from a thick crystal.

This conclusion, however, may be disputed. When we make use of a thick crystal, the ordinary and extraordinary images are separated; we study the properties of each apart. In the case of the thin plates the observer has to do with light which is mixed and complicated. Now who can affirm, without having made the experiment, that two rays really polarised at right angles, will not seem, in cases of interference, to have lost their primitive polarisations, and will not exhibit an intermediate polarisation the *result* of the others, which might be considered as *composing* it?

The reader will now have conjectured, that, in order to elucidate these mysterious phenomena, it will require to be proved, first, that two pencils are actually formed in the thin plates of crystallized substances, as well as in thicker crystals, polarised at right angles to each other; and secondly, that these pencils, when they are mixed, may exhibit the *appearance* of a polarisation intermediate between the two separate directions. Such then is the object of the very delicate experiments which are now to be related.

A pencil of homogeneous solar light being concentrated into a very small point, by the aid of a lens of a short focus, fixed in the shutter of a dark room, the pencil of diverging rays is to be received on two plates of glass slightly inclined to each other, and making an angle with the ray of about 35^0: the pencils reflected by the two plates will then be completely polarised, and where they intersect each other, they will form light and dark stripes; and whatever the position of the plates may be, the stripes will be polarised in the same direction as the two pencils which afford them.

If we now take a very transparent plate of sulphate of lime, and divide it in the middle, so as to have two plates of exactly the same thickness: if we fix one of the halves of this plate before the mirror, in such a situation that it may transmit that pencil only which is reflected by the first mirror, and so that the principal section may make an angle of 45^0 with the primitive plane of polarisation: and then the other half of the plate in the way of the polarised light reflected by the other mirror, but with its principal section at right angles to that of the other plate, and making an angle of 45° with the primitive plane in a contrary direction: *then, if these plates act in the same manner as thick plates,* however small the measure of their double refraction may be, they must divide the reflected rays which pass through them into two pencils of the same intensity, and polarised at right angles to each other: but in the positions here assigned to them, it will evidently happen that the plane of polarisation of the ordinary pencil coming, for example, from the right hand plate, will be parallel to the plane of polarisation of the extraordinary pencil of the left hand plate: and the same will be true of the two remaining pencils of the respective plates.

This being admitted, it is easy to see what will happen at the points in which the two pencils intersect each other. The ordinary rays of the right hand plate will at once interfere with the extraordinary rays of the left hand plate, since they are polarised in the same direction, and will form a group of light and dark stripes: and a second group will be afforded by the extraordinary rays of the right hand plate and the ordinary of its companion. The two groups will be the further separated from each other as the plates are thicker, and as their double refraction is more strongly marked. In the intermediate space we shall find the rays of the same description furnished by the two plates; but as they have now received contrary polarities, they intersect each other without exhibiting any of the phenomena of interference, and the eye has the sensation of a uniform light only.

A fact which is no less evident than the existence of the two systems of stripes, is, that when we employ the sulphate of lime, each of the systems is completely polarised, in a plane perpendicular to the principal section of the plate which is nearest to it.

Now there is no one of the consequences of the supposition with which we set out, that is, the supposition that every plate divides polarised light passing through it *into two pencils polarised at right angles,* that is not fully confirmed by this experiment. The truth of the hypothesis is therefore demonstrated, for every other mode of separation or of polarisation of the rays, that for example which is deduced from the principles of moveable polarisation, would lead to phenomena totally different from those which have been described.

A little attention to the passages (SECT. VII.) containing an account of the circumstances under which polarised rays are capable of occasioning appreciable effects of interference, will be sufficient to convince the reader, that the two systems of stripes which have been the subjects of these experiments can only have been the result of the interference of the ordinary rays of one plate with the extraordinary rays of the other. But if any doubts were entertained on this subject, they might be removed in the following manner.

We might substitute for the two thin plates, which have been employed, two thick crystals, for example two rhomboids of carbonate of lime, in which the double refraction would be manifest. As we might then follow separately the course of each pencil, and intercept them in turn by screens, it might thus be proved by the most direct evidence, that for the formation of the two groups of stripes, it is necessary and sufficient that the ordinary pencil of one of the crystals should meet the extraordinary pencil of the other, and the reverse. The direction of the polarisation of these fringes, determined by the aid of a rhomboid, would also be exactly the same as in the case of the employment of thin plates. The only remarkable difference between the two experiments would be in the degree of separation of the two groups of fringes. This distance, depending on the difference of the paths described by the ordinary and extraordinary rays, would be "greater" [or rather smaller] with the crystals than with the plates. It might even happen, if the crystals were very thick,

that in order to "bring the stripes within the field of view," [or to render them visible], it would be necessary to compensate for a part of the difference of the lengths of the paths, or of the velocities, by the assistance of a plane glass, fixed in the way of one of the pencils; but in every case the results of the experiment would be equally clear and decisive.

It may also be added, in the last place, as a full answer to every objection that might be raised against this explanation of the formation of the two groups of stripes, in the thin plates, that the interval which separates the two systems is always so dependent on the double refraction of the plates, that its exact numerical value may always be deduced from the elements of the double refraction, as obtained by experiments on other portions of the same substance. [See CHROMATICS.]

We must now consider how it will be possible to reconcile the experiment which has been related, and which proves the subdivision of the light into two pencils, polarised at right angles to each other, with the other fact, which seems to be opposed to it, that when the plate is of a proper thickness, the whole group of polarised rays, that pass through it, shall appear to be polarised either in the primitive plane, or in another making with it an angle of $2i$.

We make, in a dark room, a very small radiant point of homogeneous light, by means of a lens, as already mentioned. We receive the diverging pencil, on a plate of glass, having its posterior surface covered with a black varnish: supposing the plate to be in a vertical position, and the diverging pencil to be nearly horizontal, and to make an angle with the surface not much differing from that of complete polarisation: when this arrangement is completed, we place in the way of the reflected light a rhomboid of calcarious spar, its principal section making with the horizon, or with the plane of reflection, an angle of 45°. In this position of the rhomboid, the light passing through it is divided into two pencils, the one ordinary and the other extraordinary, polarised at right angles, and of equal intensity. After having passed through the first rhomboid, the two pencils fall on another rhomboid of the same thickness, but having its principal section perpendicular to that of the former. The ordinary pencil will then be subjected to the extraordinary refraction in it, and the reverse: and the two pencils will emerge from the second rhomboid, one polarised in the plane of its principal section, and the other perpendicularly to it.

Let us now follow the course of each of the pencils: in the first place it is evident that on account of their divergence, they will intersect each other in a space so much the wider as they become more remote from the rhomboid: their points of emergence being distinct, and sensibly separated, the observer may intercept in turn with a screen either the ordinary or the extraordinary pencil, and enlighten at pleasure any other object either with the one or the other separately, or with both at once.

This delicate and complicated experiment being so far advanced, let us place a glass slightly roughened, in a part of the field of view common to the two pencils: marking, by a very fine opening in an opaque plate covering the glass, the precise spot on which we fix our attention; and employing, as usual, a doubly refracting crystal to analyse the different kinds of light, which, after passing through the slit in the diaphragm, depict an image within the eye.

It will now easily be observed that the ordinary ray, when it arrives alone at the aperture, wherever it may be placed, undergoes no modification, and remains polarised as it was before: and the same is true of the extraordinary ray: but if both these rays intersect each other in the slit, and enter the eye together, the phenomenon is by no means so simple, and its nature changes according to the place occupied by the slit: so that moving this slit gradually by means of a screw, we soon find the point where the light, composed of the two pencils that pass through it, seems to be wholly polarised in the same manner as the pencil was at its first reflection from the plate of glass: further on, the plane of polarisation seems to be perpendicular to the primitive plane: and in a position intermediate between these, the rays transmitted afford no material traces of polarisation at all.

This experiment therefore offers us the singular phenomenon of two pencils, polarised at right angles, which, after having intersected each other in the ground glass, unite within the eye, and form together, as the test of the rhomboid shows, a pencil polarised sometimes in one direction, and sometimes in an opposite one, or sometimes without any sensible trace of polarisation, according to the magnitude of the difference of the paths described by the two pencils.

It is only to assist the imagination that the piece of ground glass has been supposed to be employed: for its presence is not necessary to the success of the experiment. A lens alone may be used for observing the stripes formed in the air by the interference of the luminous pencils. If, however, we merely placed ourselves with this lens before the two rhomboids, the eye would only receive a uniform and continued light: but as soon as a doubling crystal is perfectly *interposed* between the lens and the rhomboids, or between the lens and the eye, we shall observe two systems of dark and bright stripes, the bright stripes of one of the images corresponding always with the dark stripes of the other. The middle stripes, for example, will be bright in the ordinary image, *if the principal section of the interposed crystal is parallel to the primitive polarisation of the rays on the blackened glass*; and in the same case the middle stripe will be dark in the extraordinary image. The point of space, occupied by the middle of the image, seems therefore to transmit to the eye, through the crystal, only such light as is polarised in the primitive plane, because it affords only an ordinary image of the light: and this circumstance shows also that the effects of interference in the extraordinary image require, for their computation, the addition of $\frac{1}{2}d$ to the difference of the paths described.

When the principal section of the crystal interposed between the eye and the rhomboid is perpendicular to the original plane of polarisation, the two kinds of pencils interchange their effects: and in this case the central stripe of the extraordinary image is bright, and that of the extraordinary image is completely

dark, as if the difference of the paths of the rays forming it were $\frac{1}{2}d$.

It has been hitherto supposed that the original pencil contained only homogeneous light; so that it produced only bright and dark stripes. But if we employ white light, the stripes will be coloured; because d has different values for the rays of different tints; and these tints are precisely the same as are developed by polarised light in their passage through crystallized plates of all possible thicknesses.

A few words will now be sufficient to show the mode of action of these plates in the phenomena of the colours first described.

A polarised ray, passing through a crystallized plate, which possesses the power of double refraction, is divided by it, mathematically speaking, into two pencils polarised at right angles: but two pencils of this description do not interfere: the plate will therefore not exhibit colours to the naked eye, whatever its thickness may be, even when it is only exposed to polarised light: and this result is confirmed by experiment.

Each of the ordinary and extraordinary pencils, transmitted by the plate, will again be divided into two, when it passes through an achromatic prism of crystal, or a rhomboid of calcarious spar. Of these four emergent pencils, the two, which follow the ordinary path, will be no more separated than they were at their emergence from the plate: and the same is true of the two extraordinary pencils, so that the eye will ultimately perceive but two distinct images.

Of the two pencils which thus concur in the formation of the ordinary image, the one was ordinary in its passage through the plate, and has remained ordinary in the rhomboid placed near the eye, while the action of this rhomboid has been required for bringing the other pencil from the extraordinary to the ordinary refraction. The different kinds of rays have different velocities in crystals capable of double refraction; and an inequality of velocity gives rise to the phenomena of interference, as well as an inequality of distance described. If, in the plate employed, the difference between the velocities of the ordinary and extraordinary ray corresponds, either on account of its thickness or of the diversity of the two refractions, to a certain quantity, d, or its multiple, the kind of rays of which the interval nd determines the destruction, n being a whole number, will be wanting in the ordinary image transmitted by the rhomboid. And this effect, it must again be repeated, depends on the interference of the two pencils of which this image is really formed, and which, *in the plate*, possessed different velocities.

If the experiment with the two rhomboids had not taught us that in order to calculate the mutual actions of the luminous rays, which in passing through different crystals possessed of doubly refractive powers, have several times changed their planes of polarisation, the ordinary laws of interference require some modification, we should have found ourselves arrested by a considerable difficulty.

The difference of the velocities being the same for the two pencils, of which the extraordinary image afforded by the rhomboid consists, and for the two which concur in the formation of the ordinary image, it would seem that the rays of the same colour ought to be destroyed at once in both the images, and that they ought to exhibit the same tint: but if we recollect that after having calculated for one of the images the effect of interference corresponding to the difference d in the path, we are obliged, when we proceed to the other image, in order to obtain results conformable to experiment, to add $\frac{1}{2}d$ to the difference of the paths or to the effect of the difference of the velocities, this difficulty will disappear. Supposing "d"[nd] in the ordinary image to occasion the destruction of the red rays, "$d+\frac{1}{2}d$" [$nd+\frac{1}{2}d$] will correspond on the contrary to their most complete agreement in the extraordinary image, and these two images will exhibit tints rigorously complementary to each other, as the experiment shows.

The colours developed by polarised light, in passing through crystallized plates, being only, to speak correctly, portions of stripes produced by interference, we must expect to find in them, by varying the thicknesses of the plates, the same apparent deviations of the planes of polarisation, as we found in the experiment on the narrow stripes produced by means of the rays transmitted by two plates of sulphate of lime, of which the principal sections were perpendicular to each other: and it has already been remarked that this analogy is supported by observation.

It can scarcely be doubted that this explanation will readily be adopted as fully satisfactory, by all those who will give themselves the trouble to examine it with sufficient attention: and the subject may now be concluded with the formulas which express the intensities of the ordinary and extraordinary images, for the case of a polarised ray which has passed through one or two crystallized plates, with a perpendicular incidence, whatever may be the situation of their principal sections.

For a single plate, making unity the intensity of the primitive homogeneous pencil; i the angle made by the principal section of the plate with the primitive plane of polarisation; s the angle made by this same plane with the principal section of the rhomboid or of the achromatic prism, by means of which we analyse the emergent light: $o-e$ the difference of the paths of the ordinary and extraordinary rays at their emergence: d the interval already explained, and π the circumference of the circle of which the diameter is unity: we shall then have,

For the ordinary image, $\cos^2 s - \sin 2i \sin 2(i-s) \sin^2 \pi . \frac{o-e}{d}$.

For the extraordinary image, $\sin^2 s + \sin 2i \sin 2(i-s) \sin^2 \pi . \frac{o-e}{d}$.

When the polarised pencil has passed through two plates, there must be an additional element in the formula, that is, the angle formed by the principal section of this second plate with the primitive plane of polarisation: let this angle be t, all the others retaining the same symbols, and let $o'-e'$ be the difference of the paths belonging to the second plate: the intensity of the ordinary image afforded by a pen-

cil of homogeneous light will then be represented by

$$\cos^2 s + \sin 2t \sin 2i \cos 2(t+i-s) \sin^2\pi\frac{o-e}{d} - \sin 2t \cos 2i \sin 2(t+i-s) \sin^2\pi\frac{o'-e'}{d} - \cos^2 t \sin 2i \sin 2(t+i-s) \sin^2\pi.\frac{o-e+o'-e'}{d} + \sin^2 t \sin 2i \sin 2(t+i-s) \sin^2\pi.\frac{o-e-(o'-e')}{d}$$

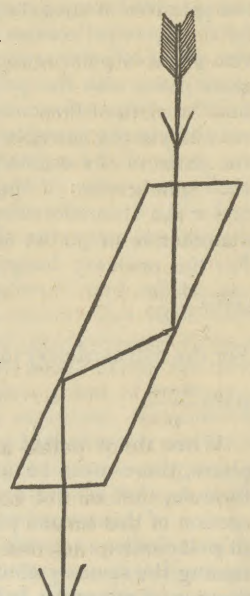
: and the intensity of the extraordinary image is found by subtracting this expression from unity.

If we calculate separately, according to these formulas, the intensities of the rays of the different colours which compose white light, we obtain the *tint* of the ordinary or of the extraordinary pencil, whether the light, previously polarised, has passed through one or two crystallized plates: and if, in this calculation, we employ for $o-e$ and for $o'-e'$ the values corresponding to the *individual* double refractions to which the different species of rays are subject, we shall find the *most perfect agreement* between the formulas and the experiments, even in those crystals which afford tints that appear to bear *no resemblance* to those of the coloured rings of Newton.

The phenomena of these thin plates therefore, which seemed to some persons to afford an unexceptionable demonstration of the system of emission; which seemed to require the assistance of the most singular oscillations of the molecules of light; which seemed to enable them to discover, in those particles, an axis of rotation, a pair of poles, and an equator; and even a kind of precession of the equinoctial points: these phenomena are in fact only, as we have just seen, the immediate and unavoidable consequences of the simple but inexhaustible laws of interference.

Sect. X.—*On* Circular *Polarisation.*

The kind of polarisation which is now to be considered differs essentially from those which have been hitherto examined.



Suppose that, having polarised a pencil of light, we cause it to undergo twice over, at the angle of 54°, a total reflection within a parallelepiped of glass, as seen in the figure: the new planes of reflection being also supposed to be inclined at an angle of 45° to the plane of primitive polarisation: the emergent pencil will then have acquired some particular properties, which are very remarkable.

When this emergent pencil is analysed with a rhomboidal crystal, it is *constantly* decomposed into two rays of the same intensity, whatever may be the direction of the principal section. From this circumstance it might be supposed that it had resumed the character of ordinary light: but if it be transmitted through a crystallized plate before it is subjected to the action of the rhomboid, we shall soon perceive a distinction: for in this case, common white light would afford two white images, of the same intensity; while the light of the parallelepiped is divided into two pencils, both strongly coloured.

This new kind of rays has also some other peculiarities. It has already been remarked (Sect. V.) that one or more total reflections make no difference in the properties of ordinary light; but they modify, on the contrary, in a remarkable manner, the pencil which has passed through the parallelepiped: for this pencil resumes all the qualities of polarised light when it has been subjected to two total reflections similar to the first, whatever may be the azimuth of the latter planes of reflection with regard to the former.

The pencil of light in question is decomposed, then, into two coloured images, when it is only analysed by a rhomboid after having been transmitted through a crystallized plate: but it must be remarked that the colour of each of these images, on the chromatic circle of Newton, is about one fourth of the circumference distant from the place which the colour of the same image would have occupied, if we had employed only common polarised light.

It may also be added, as another distinguishing character, that this last kind of light gives rise to no phenomena of colour after being transmitted through plates of rock crystal perpendicular to the axis, or through columns of oil of turpentine or of other essential oils.

A polarised ray, modified by two total reflections, has therefore some very particular characters, which distinguish it equally from a direct ray, and from an ordinary polarised ray: and as these characters have no relation to the different sides of the ray, the modification, thus obtained, has received the name of *circular polarisation.* If any person should think the denomination too little supported by the facts described, he may be informed that it has been partly derived from some theoretical considerations, which appear to justify it.

The mode of obtaining the circular from the ordinary polarisation by means of two total reflections having been described, there remains to be mentioned a very remarkable method of procuring the circular polarisation more immediately from common light.

We cut out of a column of rock crystal a very obtuse prism with its two faces forming an angle of about 150°, and equally inclined to the axis of the column, and we make it achromatic as well as we can with two prisms of glass cemented to its opposite faces: or since this method must always be imperfect, we employ, instead of the glass, two other prisms of rock crystal, taken from pieces which possess the opposite qualities which have been described in speaking of plagiedral crystals; and this arrangement has also the advantage of a separation of the images to a double distance. We obtain by means of this little combination the effects of double refraction; but the

two pencils to which it gives birth, when they have been transmitted in a direction parallel to the axis of the column, have not acquired the same modification which Iceland spar, for example, would produce in them, but they are *circularly* polarised. Thus, if we analyse them with a rhomboid, they are always divided into two pencils of equal intensity, and when they have undergone two total reflections within a parallelepiped of glass at an angle of incidence of 54°, they are found completely polarised in two planes inclined 45° to the plane of reflection, the plane of polarisation of the one being to the right, and that of the other to the left.

There exists, therefore, a particular kind of double refraction which communicates to the rays of light a circular polarisation, as the double refraction of the Iceland crystal produces in them the ordinary polarisation.

It follows, besides, from all the phenomena of this class, and from the general laws of interference, that a pencil circularly polarised may be considered as composed of two ordinary pencils polarised at right angles, one of them, however, being supposed to be retarded in its path, in comparison with the other, by a quarter of the interval which has been already denoted by d.

The properties of rays circularly polarised afford us a very curious mode of reproducing exactly all the phenomena of colours, that we have observed in the plates of rock crystal, cut perpendicularly to the axis, and in certain liquids.

For this purpose we must place a thin crystallized plate between two parallelepipeds of ordinary glass crossed at right angles, and similar to that which has been already represented by a figure. A pencil, passing perpendicularly through the first parallelepiped, undergoes within it two total reflections at the angle of 54°; after its emersion, it is transmitted by the crystallized plate, and further on it enters the second parallelepiped, and is again twice reflected within it; but in a plane perpendicular to that of the former reflections: at last it emerges into the air, perpendicularly to the last surface of the parallelepiped. Now we may always obtain, in the emergent ray, the appearances of a polarised ray which has passed through a plate of rock crystal cut perpendicularly to the axis, or a certain depth of the essential oil of turpentine: and it will be sufficient for this purpose, that the pencil incident upon the first parallelepiped should be previously polarised, and that the axis of the interposed crystalline plate should make an angle of 45° with the two planes of the total reflections.

[SECT. XI.—*Enumeration of the* PRINCIPAL MINERALS *which are possessed of particular Properties with respect to Polarisation.* Added by the Translator.

i. All such regular crystals as belong to the rhomboidal or pyramidal systems of crystallization, described by Mohs, are found to have one axis of double refraction, coincident with the crystallographic axis of these solids.—(Brewster's *Edinburgh Encyclopædia*, Article OPTICS, p. 572.) The axis of a refraction governed by the law of the *oblate* spheroid is called by Dr Brewster a *negative axis;* by M. Biot a *repulsive axis;* and the axis of the oblong spheroid a *positive* or an *attractive* axis; the crystals are distinguished by the signs — and + respectively.

1. Rhomboid with obtuse summit.

— Carbonate of lime.	— Carbonate of lime and iron.
— Carbonate of lime and magnesia.	— Tourmaline.
— Rubellite.	Ruby silver.
+ Dioptase.	

2. Rhomboid with acute summit.

— Corundum.	— Ruby.
— Sapphire.	Cinnabar.

3. Regular hexaedral prism.

— Emerald.	— Nepheline, or Sommite.
— Beryl.	— Arseniate of copper.
— Phosphate of lime.	— Arseniate of lead.

4. Octaedron with a square base.

+ Zircon.	— Mellite.
+ Oxyd of tin.	— Molybdate of lead.
+ Tungstate of lime.	— Octohedrite.

5. Right prism with a square base.

+ Titanite.	— Meionite.
— Idocrase.	Uranite.
— Wernerite.	

6. Bipyramidal dodecaedron.

+ Quartz.	— Phosphato-arseniate of lead.
— Phosphate of lead.	

ii. Besides the crystals belonging to these classes, there are others of which the primitive form has not been determined, but in which the position of the single axis of double refraction has been ascertained.

Crystals.	*Axis of Double Refraction.*
— Mica from Kariat.	Perpendicular to the laminae.
— Mica with amianthus.	Perpendicular to the laminae.
— Hydret of strontia.	Perpendicular to the quadrangular plate.
— Arseniate of potass.	Axis of quadrangular prism.
— Muriate of lime.	Axis of hexaedral prism.
— Muriate of strontia.	Axis of hexaedral prism.
— Nitrate of soda.	Axis of obtuse rhomb.
— Subphosphate of potass.	Axis of quadrangular prism.
— Sulfate of nickel and copper.	Axis of quadrangular prism.
— Hyposulfate of lime *(Herschel.)*	Axis of hexagonal tables.
+ Boracite.	Axis of cubical rhomb.
+ Apophyllite from Uton.	Axis of prism.
+ Apophyllite surcomposée.	Perpendicular to the plate.
+ Sulfate of potass and iron.	Axis of hexaedral prism.
+ Superacetate of copper and lime.	Axis of prism.
+ Hydret of magnesia.	Perpendicular to the laminae.
+ Ice.	Axis of hexaedral prism or rhomb.

iii. The crystals which have been enumerated appear to be symmetrical with respect to a single axis, so as to have similar properties in every plane passing through that axis: but Dr Brewster discovered in 1816 that in a great multitude of crystals the refractive powers are different in different planes passing through the principal axis; the phenomena and the laws of refraction being such as may be explained from the combined effects of two axes perpendicular to each other, and unequal in the ellipticity of the spheroids to which they belong.

"All regular crystals which belong to the *primitive* system of Mohs, or whose primitive forms are the *right prism*, with its base a rectangle, a rhomb, or an oblique parallelogram; the *oblique prism*, with its base a rectangle, a rhomb, or an oblique parallelogram; or the *rectangular and rhomboidal octaedron*, have *two* axes of double refraction, coincident with some permanent line in the primitive form."

1. Thus, all the combinations of the sulfuric, tartaric, and acetic acids, with single earthy, metallic, and alkaline bases, have two axes of double refraction.

2. The two *apparent* axes of crystals with two axes [or the lines in which the double refraction seems to be neutralised] have no symmetrical relation either with the faces or prominent lines of the primitive or secondary forms of minerals.

3. The two *rectangular* axes, the principal one of which is in the same plane with the two apparent axes, and *equidistant* from them, have a constant symmetrical relation to the faces and axes of the primitive forms in which they crystallize.

4. The line exhibited at any point of the sphere, by the joint properties of two axes, is represented by the diagonal of a parallelogram, of which the sides correspond to the tints belonging to the separate axes, and make with each other an angle twice as great as the angle formed by the planes passing through the given point and the two axes: and the increment or decrement of the square of the velocity of the light may be computed in the same manner as this line representing the tint.

iv. The necessity of any very minute investigation of the properties of particular substances, with regard to double refraction, is in great measure superseded by the very important facts first observed by Dr Brewster in 1814 and 1815, relating to the effects of heat and of compression in producing double refraction and polarisation. He found that compression was capable of producing colour when a soft animal jelly was only touched by the finger: and that when a "negative" crystal, like that of the carbonate of lime, is compressed in the direction of the axis, the tints that it affords "descend," and that they "rise" when it is dilated: whence it seems to follow, that simple dilatation of a homogeneous substance in a given line will constitute that line the axis of an oblate spheroid: but the results require to be distinguished by a greater variety of experiments. M. Fresnel has succeeded in exhibiting not only colours by a strong pressure, but a very manifest reduplication of the image of a line, seen through a piece of glass strongly compressed by screws: and he performed this experiment very successfully at a meeting of the Parisian Academy of Sciences in 1822.]

SECT. XII.—HISTORICAL DETAILS *respecting the Discovery of the Different Properties of Light concerned in* POLARISATION.

It will now be necessary to enumerate the natural philosophers to whom we are indebted for the discoveries, of which the importance has been explained in this article: and it will be convenient to do this in the order of the sections.

i. HUYGENS appears to be the first person that observed, in the two pencils derived from a single one, by means of double refraction, the existence of particular properties after their passage through the crystal, which they did not possess when they entered it. "It seems," he says, "that we are obliged to conclude, that the undulations of light, by passing through the first crystal of Iceland spar, acquire a certain form, or a certain disposition, by which, when they fall on the substance of a second crystal, in a certain position, they are enabled to affect both the kinds of matter which serve for the two species of refraction, and when they fall on it in another position, they only act on one of these substances."

Thus, according to this great philosopher, in the act of double refraction, the undulation, or the ray, changes its *form*, and loses its symmetry, so as to give room for the distinction of its different *sides*, or, changing the expression only, its different *poles*.

Huygens is therefore the first that observed a phenomenon of polarisation, and this discovery was made in 1678, though it was only published in 1690. From the time of Huygens to the year 1809, no observer, with the exception of the immortal author of the *Opticks*, had studied the subject of double refraction in this point of view: and it must even be acknowledged that, with respect to the facts in question, nothing was added by Newton to what the Dutch mathematician had discovered. He only insisted much more strongly on the necessity of admitting poles in each of the rays, derived from the subdivision, which light undergoes, in passing through an Iceland crystal. To MALUS belongs the honour of having brought back the attention of natural philosophers to the properties of light which form the subject of this article. It was he that first pointed out the singular phenomena exhibited by the ordinary and extraordinary rays when they meet with transparent reflecting surfaces, at certain inclinations: and it is to him that we are indebted for the mathematical law, which appears to connect intensities of the different pencils, into which the light is divided, when it passes through two rhomboids of the spar in succession. (*Mémoires d'Arcueil*, II. 8vo. Par. 1809.)

ii. The anecdote, which has been often told, of the fortunate circumstance that led MALUS to the discovery of the polarisation of light by reflection from transparent substances, is perfectly correct. This philosopher, so early arrested in his pursuit of science by a premature death, and so universally lamented by his friends, has often related to the author of this article, that as he happened to be decomposing, by means of a rhomboid of carbonate of lime, towards

the end of the year 1808, the light of the setting sun, reflected from the glass of the windows of the Luxembourg, he first observed the difference of the intensity of the two images in different positions of the rhomboid: but it is not true, as has sometimes been stated, that one of the images actually disappeared in this observation; for the polarisation of the light, at the moment of the experiment, was only partial. A similar difference of intensity must have been before the eyes of mineralogists whenever they had been trying to examine the double refraction of crystals, and had projected the needle, which they used for an object of view, on a clear and serene sky, which affords a curtain of polarised light. But the fact had not excited their attention. Malus observed it, was struck with all its importance, completely analysed it in all its forms, with the most singular sagacity, and thus became the creator of a new branch of optics. It is to this celebrated observer that we are indebted for all the experiments related in the second section. (*Mémoires d'Arcueil*, II.)

iii. The measurements related in the third section, which appear to show that at equal angular distances above and below the angle of complete polarisation, the reflected rays contain nearly equal quantities of polarised light, were obtained by Mr Arago.

iv. It was Dr Brewster that discovered the remarkable law, which connects the angle of complete polarisation with the refractive density of the substance. It was communicated to the Royal Society on the 16th March 1815. (*Philosophical Transactions*, 1815.)

The relation of the angle of complete polarisation at the second surface of a transparent medium to the angle belonging to the first surface, had before been shown by Malus. (*Mém. d'Arc.* II.) The same relation may be extended to the angles, at the same surfaces, which afford polarisation of *equal proportions* of the light falling on them. So that the rule given by Malus is only a particular case of a general theorem, which Mr Arago has deduced from a long series of experiments that have not been published.

v. It was discovered also by Malus that the pencil *transmitted* by a transparent plate is partially polarised in a plane at right angles to the plane of polarisation of the reflected pencil. This fact was communicated to the Institute on the 11th March 1811, and published the next day in the *Moniteur*. See also the *Memoirs of the Mathematical Class* for 1810. The photometrical experiments of Mr Arago have established a relation between these two kinds of polarisation which had been unobserved by Malus: it is contained in this simple enunciation. "The quantity of polarised light contained in the pencil, which any transparent plate transmits, is exactly equal to *the quantity* polarised in the contrary direction, which is found in the light reflected by the same plate." These experiments were made in 1812, but they were first published in 1814 by M. Biot, to whom M. Arago had communicated them. (See *Recherches Expérimentales et Mathématiques sur les Mouvemens des Molécules de Lumiere.* 1814.)

It follows from this law, as Mr Arago had also observed, that at the angle of total reflection, and at all greater obliquities, the light wholly escapes polarisation.

The phenomena exhibited by piles of plates were analysed by Malus, immediately after his discovery of polarisation by refraction.

The observation that some natural bodies, agates for example, act on light precisely like these piles of plates, is due to Dr Brewster. (*Treatise on New Philosophical Instruments.* 8. Edin. 1813.)

vi. The laws and experiments related in the sixth section belong to Mr Fresnel. Malus had before attempted to discover in what manner the planes of polarisation changed their directions: but there are several inaccuracies in the results which he has published. (*Mém. Inst.* 1810.) The formulae of Mr Fresnel are some of the most valuable additions that have been made of late to the science of optics. A general account of the deviations undergone, in reflection, by the plane of polarisation of a ray, previously polarised, is found in two Memoirs presented to the Academy by Mr Fresnel, on the 24th November 1817 and the beginning of January 1818: but the mathematical laws of the phenomena were not discovered and published till 1821. (See *Annales de Chimie et de Physique.* XVII.)

vii. Mr Arago and Mr Fresnel are hitherto the only philosophers who have examined the effect of polarisation in modifying the phenomena of interference. The Memoir, in which they first recorded the results which are inserted in the seventh section, appeared in the *Annales de Chimie* for 1819, Vol. X.

viii. It was Mr Arago that first observed the changes in the properties of polarised rays when they pass through crystalline plates; he showed that they acquire the property of being divided by calcarious spar into two coloured pencils, and of being reflected by transparent substances with tints which vary according to the angular position of their surfaces. His Memoir was read to the Institute on the 11th of August 1811, and printed in the volume of the *Memoirs* of that year.

Dr Brewster published some similar experiments in his *Treatise on Philosophical Instruments*, which appeared in 1813. He says that they were made before he had seen Mr Arago's paper, and even "before any of his countrymen had any knowledge of what had been done in France." (*Edinburgh Encyclopædia*, Art. Optics, p. 587.) We must take Dr Brewster's word for the first part of this assertion; but since an extract of Mr Arago's *Memoir* was inserted in the *Moniteur*, on the 30th August 1811, there would be some difficulty in *proving* the truth of the second part.

The phenomena exhibited by plates, cut perpendicularly to the axis, were also described by Mr Arago in the same Memoir.

We are indebted to Mr Biot for the rule, according to which the deviation of the poles is effected, whether on account of the particular kind of "each luminar molecule," or on account of the more or less considerable thicknesses of the plates by which these "molecules" have been transmitted. His *Memoir* was read to the Institute in September 1818, and printed shortly after.

Mr Herschel is the author of the curious observation relating to the facets of plagiedral crystals. (*Transactions of the Philosophical Society of Cambridge*, I.)

The extension of the properties of plates perpendicular to the axis, by which they are assigned to the strata of certain liquids, was made by Mr Biot in 1815. (*Bulletin des Sciences*, Dec. 1815.)

ix. The laws of the depolarisation produced by crystallized plates, parallel to the axis, are reduced to the three following.

1. The motion of the plate in its plane does not alter the tints of the images furnished by a rhomboid. This result is implicitly comprehended in the first *Memoir* of Mr Arago; since in the description of all the motions which cause a change of the tints, the motion of the plate in its own plane is not included.

2. The tints of the two images are those of the coloured rings of Newton, seen by reflection or by transmission. This law had been laid down by Mr Biot; but Mr Herschel has shown in the *Cambridge Transactions* that it is not universally true: so that its theoretical importance is lost.

3. In a crystal of variable thickness, the same phenomena of polarisation are reproduced at thicknesses which form a series like that of the coloured rings of Newton. When we examine with a rhomboid a crystal cut in a proper manner, so that two of its faces form an angle, and which is projected on a back ground affording polarised light, each image appears bordered by regular streaks, parallel to the angular edge of the prism, and separated by equal spaces. Mr Arago, when he described this phenomena in August 1811, advanced it as a sufficient proof of this third law. The Academy of Sciences, and Mr Laplace in particular, did not admit the conclusion as demonstrated, and a direct admeasurement of the thicknesses was required. Count Rumford, who was present, offered the use of an instrument which he had employed for some other purposes, and which seemed to promise a sufficient degree of precision: the common comparer was also mentioned as proper for the purpose. Mr Arago, upon these suggestions, undertook to make these further experiments. But Mr Biot anticipated him: and he has *therefore* a claim to the *first direct demonstration* of the law of the thicknesses.

4. The brilliant tints of each of these images may be calculated from the laws of interference, according to the difference of the paths and of the velocities of the ordinary and extraordinary rays. This important remark is due to Dr Thomas Young, who is believed to have published it in the *Quarterly Review*, XI. 1814, p. 42, 49.

It affords the true key of all these phenomena. It must however be added that Dr Young had not explained either in what circumstances the interference of the rays can take place, nor why we see no colours unless the crystallized plates are exposed to light previously polarised. The new properties, which required to be combined with the ordinary laws of interference, in order to obtain a *complete* explanation of the facts, were discovered by Mr Arago and Mr Fresnel, as they have been described in the seventh section. The dates of the *Memoirs*, in which Mr Fresnel published this explanation, are 1816 and 1818.

The ingenious and delicate experiments, which have been employed as tests of the inaccuracy of the theory of moveable polarisation, are also due to Mr Fresnel, one of the most inventive theorists as well as one of the most skilful experimenters that have devoted themselves to science in this or in any age: the formulæ found at the end of the section are also Mr Fresnel's.

x. The phenomena of circular polarisation were discovered by Mr Fresnel, who described and analysed them in a *Memoir* read to the Academy of Sciences in November 1817, and in January 1818. His later researches on this subject are inserted in the *Bulletin* of the Philomathic Society, December 1822 and February 1823.

There are a few other particulars, relating to the developement of tints by repeated reflections at the surfaces of metallic mirrors; to the rings seen in crystallized plates cut perpendicularly to the axis when examined with a rhomboid held very near them; and to the phenomena of the absorption of polarised light by certain crystals. The first have hitherto been reduced to no *direct* analogy with other affections of polarised light: the second seem to be derived from a modification of the laws already explained in the ninth section; the discovery of the scattered phenomena belonging to the third head has been disputed by Mr Biot and Dr Brewster, but they appear to have been first observed by Mr Arago in 1814. (See Biot's *Recherches sur les Mouvemens des Molécules de Lumiere*. 4to. Paris, 1814. P. lxxxvi.)

[Sect. XIII.—Theoretical *Investigations intended to* Illustrate *the Phenomena of Polarisation*. Added by the Translator.

We are led, from the facts which have been enumerated in the 11th Section, to the remarkable coincidence between the discoveries of Dr Brewster respecting crystals with two axes, and a theory which had been published a few years *earlier* in order to illustrate the propagation of an undulation in a medium compressed or dilated in a given direction only, and to prove that such an undulation must necessarily assume a spheroidal form upon the mechanical principles of the Huygenian theory. As every contribution to the investigation of so difficult a subject may chance to be of some value, it will be worth while to copy this demonstration here, from the *Quarterly Review* for November 1809, Vol. II. p. 345.

"The proposition to be demonstrated was this: *An impulse is propagated through every perpendicular section of a lamellar elastic substance in the form of an elliptic undulation.*

"When a particle of the elastic medium is displaced in an oblique direction, the resistance, produced by the compression, is the joint result of the forces arising from the elasticity in the direction of the laminae, and in a transverse direction: and if the

elasticities in these two directions were equal, the joint result would remain proportional to the displacement of the particle, being expressed, as well in magnitude as in direction, by the diagonal of the parallelogram, of which the sides measure the relative displacements, reduced to their proper directions, and express the forces which are proportional to them. But when the elasticity is less in one direction than in the other, the corresponding side of the parallelogram expressing the forces must be diminished, in the ratio which we may call that of 1 to m; and the diagonal of the parallelogram will no longer coincide in direction with the line of actual displacement, so that the particle displaced will also produce a lateral pressure on the neighbouring particle of the medium, and will itself be urged by a lateral force. This force will however have no effect in promoting the direct propagation of the undulation, being probably employed in gradually changing the direction of the actual motions of the successive particles; and the only efficient force of elasticity will be that, which acts in the direction in which the undulation is advancing, and which is expressed by the portion of the line of displacement, cut off by a perpendicular falling on it from the end of the diagonal of the parallelogram of forces; and the comparative elasticity will be measured by this portion, divided by the whole line of displacement. Calling the tangent of the angle formed by the line of displacement with the line of greatest elasticity t, the radius being 1, the force in this line being also 1, the transverse force will be expressed by mt, the line of displacement by $\sqrt{(1+tt)}$, its diminution by $\frac{(1-m)tt}{\sqrt{(1+tt)}}$, the diminished portion, which measures the force, by $\sqrt{(1+tt)}-\frac{(1-m)tt}{\sqrt{(1+tt)}}$, and the elasticity, in the given direction, by $\frac{1+mtt}{1+tt}$. Hence it follows, that the velocity of an impulse, moving in that direction, will be expressed by $\sqrt{\frac{1+mtt}{1+tt}}$.

"It is next to be proved, that the velocity of an elliptical undulation, increasing so as to remain always similar, by means of an impulse propagated always in a direction perpendicular to the circumference, is such as would take place in a medium thus constituted. It is obvious that the increment of each of the diameters of the increasing figure must be proportional to the whole diameter; and this increment, reduced to a direction perpendicular to the curve, will be proportional to the perpendicular falling on the conjugate diameter, which will measure the velocity. We are therefore to find an expression for this perpendicular, when it forms an angle with the greater axis, of which the tangent is t. Let the greater semiaxis be 1, and the smaller n: then the tangent of the angle formed with the greater axis by the conjugate diameter, being $\frac{1}{t}$; the tangent of the angle subtended by the corresponding ordinate of the circumscribing circle is found $\frac{1}{nt}$; and the semidiameter itself, equal to unity, reduced in the ratio of the secants of these angles; that is, to $n\sqrt{\frac{1+tt}{1+nntt}}$; but, by the known property of the ellipsis, the perpendicular required is equal to the product of the semiaxis, divided by this semidiameter, that is, to $\sqrt{\frac{1+nntt}{1+tt}}$: we have therefore only to make $nn=m$, and the velocity in the given medium will always be such as is required for the propagation of an undulation, preserving the form of similar and concentric spheroids, of which the given ellipsis represents any principal section.

"If the whole of the undulation were of equal force, this reasoning would be sufficient for determining its motion: but when one part of it is stronger than another, this superiority of pressure and motion will obviously be propagated in the direction of the actual resistance produced by the displacement of the particles, since it is this resistance which carries on the pressure, and consequently propagates the motion. It is very remarkable that the direction of the resistance will be found, on the supposition which has been advanced respecting the constitution of the medium, to coincide every where with the diameters of the ellipsis, when the displacement is perpendicular to the surface. For it is proved by authors on conic sections, that the subnormal of the ellipsis is to the absciss, as the square of the lesser axis is to the square of the greater, that is, in this case, as nn to 1, or as m to 1; but if we divide the ordinate in the same ratio of m to 1, and join the point of division with the extremity of the subnormal, this line, which will evidently be parallel to the diameter, will express, as we have already seen, the direction of the force, when the normal represents that of the displacement. An immediate displacement in the direction of any diameter, making an angle with the axis of which the tangent is t, would give a velocity of $\sqrt{\frac{1+mtt}{1+tt}}$, while the increment of the diameter would require a velocity of $\sqrt{\frac{m+mtt}{m+tt}}$, which does not vary in the same proportion. It must, however, be remembered, that the rectilinear direction of the beam is not supposed to depend on this circumstance alone: Huygens considers each point of the surface of the crystal, on which a beam of light impinges, as the centre of a new undulation, which spreads in some measure, in every direction, but produces no perceptible effect except where it is supported by, and cooperates with, the neighbouring undulations; that is, in the surface which is a common tangent of the collateral undulations; but if this principle were applied to extraordinary refraction without the assistance of the obliquity of force, which may be deduced from the supposition of a stratified medium, it would lead us to expect that the elementary impulses, being propagated in a curvilinear trajectory, might be intercept-

ed by an object not situated in the rectilinear path of the beam; a conclusion which is not warranted by experiment."

However satisfactorily this mode of viewing the extraordinary refraction may be applied to the subsequent discoveries relating to the effects of heat and compression, there is another train of ideas, which arises more immediately from the phenomena of polarisation, and which might lead us to a more distinct notion of the separation of the pencil into two or more portions, though it does not seem to comprehend so entirely the phenomena depending on spheroical undulations.

We may begin this mode of considering the subject in the words which have already been employed in the Article CHROMATICS, p. 161. "If we assume as a mathematical postulate, in the undulatory theory, without attempting to demonstrate its physical foundation, that a transverse motion may be propagated in a direct line, we may derive from this assumption a tolerable illustration of the subdivision of polarised light by reflection in an oblique plane. Supposing polarisation to depend on a transverse motion in the given plane; when a ray completely polarised is subjected to simple reflection in a different plane, at a surface which is destitute of any polarising action, and which may be said to afford a neutral reflection, the polar motion may be conceived to be reflected, as any other motion would be reflected at a perfectly smooth surface, the new plane of the motion being always the image of the former plane; and the effect of refraction will be nearly of a similar nature. But when the surface exhibits a new polarising influence, and the beams of light are divided by it into two portions, the intensity of each may be calculated, by supposing the polar motion to be resolved instead of being reflected, the simple velocities of the two portions being as the cosines of the angle, formed by the new planes of motion with the old, and the energies, which are the true measure of the intensity, as the squares of the sines. We are thus insensibly led to confound the intensity of the supposed polar motion with that of the light itself; since it was observed by Malus, that the relative intensity of the two portions, into which light is divided under such circumstances, is indicated by the proportion of the squares of the cosine and sine of the inclination of the planes of polarisation. The imaginary transverse motion must also necessarily be alternate; partly from the nature of a continuous medium, and partly from the observed fact, that there is no distinction between the polarisations produced by causes precisely opposed to each other, in the same plane." Another analogous hint is found in the *Philosophical Transactions for* 1818, p. 273. "Supposing the experiments to be perfectly represented by [Dr Brewster's] general law, it will follow that the tint exhibited depends not on the difference of refractive densities in the direction of the ray transmitted, but on the greatest difference of refractive densities in directions perpendicular to that of the ray. These two conditions lead to the same result, where the effect of one axis only is considered, but they vary materially where two axes are supposed to be combined . . . There can be little doubt that the direction of the polarisation, in such cases, must be determined by that of the greatest and least of the refractive densities in question:" a "supposition," which Dr Brewster finds "quite correct."

We may add again to these hints the consideration, that when simple pressure or extension in the direction of any given axis produces a spheroidal undulation in a medium before homogeneous, this state is always accompanied by the condition, that a ray describing the axis, while the densities in all transverse directions remain equal, undergoes no subdivision, but that a ray moving in the plane of the equator, to which the perpendiculars are the axis and another equatorial diameter, undergoes the greatest possible separation into parts that are respectively polarised in the planes passing through these directions.

From these phenomena we are led to be strongly impressed with the analogy of the properties of sound, as investigated cursorily by Mr Wheatstone, and in a more elaborate manner by the multiplied experiments of Mr Savart, which have shown that, in many cases, the elementary motions of the substances transmitting sound are transverse to the direction in which the sound is propagated, and that they remain in general parallel to the original impulse.

The next transition carries us from the *mathematical postulate* here mentioned to the *physical condition* assumed by Mr Fresnel, that the relative situation of the particles of the etherial medium with respect to each other, is such as to produce an elastic force tending to bring back a line of particles, which has been displaced, towards its original situation by the resistance of the particles *surrounding the line*, and at the same time to impel these particles in its own direction, and in that direction only, or principally, while the aggregate effect is propagated in concentric surfaces.

This hypothesis of Mr Fresnel is at least very ingenious, and may lead us to some satisfactory computations: but it is attended by one circumstance which is perfectly *appalling* in its consequences. The substances on which Mr Savart made his experiments were *solids* only; and it is only to solids that such a *lateral* resistance has ever been attributed: so that if we adopted the distinctions laid down by the reviver of the undulatory system himself, in his *Lectures*, it might be inferred that the luminiferous ether, pervading all space, and penetrating almost all substances, is not only highly elastic, but absolutely solid!!! The passage in question is this: (Vol. I. p. 627.)

"The immediate cause of solidity, as distinguished from liquidity, is the lateral adhesion of the particles to each other, to which the degree of hardness or solidity is always proportional. This adhesion prevents any change of the relative situation of the particles, so that they cannot be withdrawn from their places, without experiencing a considerable resistance from the force of cohesion, while those of liquids may remain equally in contact with the neighbouring particles, notwithstanding their change of form. When a perfect solid is extended or compressed, the particles, being retained in their situa-

tions by the force of lateral adhesion, can only approach directly to each other, or be withdrawn further from each other; and the resistance is nearly the same, as if the same substance, in a fluid state, were inclosed in an unalterable vessel, and forcibly compressed or dilated. Thus the resistance of ice to extension or compression is found by experiment to differ very little from that of water contained in a vessel; and the same effect may be produced even when the solidity is not the most perfect that the substance admits; for *the immediate resistance of iron or steel to flexure is the same, whether it may be harder or softer*. It often happens, however, that the magnitude of the lateral adhesion is so much limited, as to allow a capability of extension or compression, and it may yet retain a power of restoring the bodies to their original form by its reaction. This force may even be the principal or the only source of the body's elasticity: thus when a piece of elastic gum is extended, the mean distance of the particles is not materially increased . . and the change of form is rather to be attributed to a displacement of the particles than to their separation to a greater distance from each other, and the resistance must be derived from the lateral adhesion only: some other substances also, approaching more nearly to the nature of liquids, may be extended to many times their original length, with a resistance continually increasing; and in such cases there can scarcely be any material changes of the specific gravity of these substances. Professor Robison has mentioned the juice of bryony as affording a remarkable instance of such viscidity.

"It is probable that the immediate cause of the lateral adhesion of solids is a symmetrical arrangement of their constituent parts: it is certain that almost all bodies are disposed, in becoming solid, to assume the form of crystals, which evidently indicates the existence of such an arrangement; and all the hardest bodies in nature are of a crystalline form. It appears, therefore, consistent both with reason and with experience to suppose, that a crystallization more or less perfect is the universal cause of solidity. We may imagine, that when the particles of matter are disposed without any order, they can afford no strong resistance to a motion in any direction; but when they are regularly placed in certain situations with respect to each other, any change of form must displace them in such a manner, as to increase the distance of a whole rank at once; and hence they may be enabled to cooperate in resisting such a change. Any inequality of tension in a particular part of a solid is also probably so far the cause of hardness, as it tends to increase the strength of union of any part of a series of particles which must be displaced by a change of form."

It must however be admitted, that this passage by no means contains a demonstration of the total incapability of fluids to transmit any impressions by lateral adhesion, and the hypothesis remains completely open for discussion, notwithstanding the apparent difficulties attending it: which have appeared to bring us very near to the case stated in the same Lectures as a possible one, that there may be independent worlds, some existing in different parts of space, others *pervading each other unseen and unknown in the same space*. We may perhaps accommodate the hypothesis of Mr Fresnel to the phenomena of the ordinary and extraordinary refraction, by considering the undulations as propagated through the given medium in two different ways; some by the divergence of the elementary motions in the direction of the ray, and others by their remaining parallel to the direction of the impulse or of the polarisation: the former must be supposed to furnish the spheroidal, the latter the spherical refraction. It would indeed follow that the velocity of the spherical undulation ought to vary by innumerable degrees, within certain limits, according to the direction of the supposed elementary motion: while in fact the actual velocity of the spherical undulations seems to be uniformly equal to the velocity in the direction of the axis; but this objection may be obviated by supposing the surface so constituted, that for some unknown reason the parallel elementary motion can only be propagated in the regular manner when it takes place in the direction of the axis, or when it is made to assume that direction: a condition not very simple or natural, but by no means inconceivable: unless we saw any reason to consider the adhesion as a constant force, independent of the direction, and equal to the least or greatest elasticity, or unless it were possible to derive the phenomena of two supposed axes of polarisation, which Mr Fresnel has explained on the hypothesis of two spheroids, from the supposition of two spherical undulations propagating oblique elementary motions in the direction of the actual polarisation as already determined for these crystals.

If these conjectures should be found to afford a single step, in an investigation so transcendently delicate, it will be best to pause on them for a time, and to wait for further aid from a new supply of experiments and observations.] (x.x.x.)

THE END.

ERRATA.

VOL. I.

PREFACE, in some copies, p. 6, line 19, *for* in point of structure, *read* in point of method.
——————— —— line 26, *for* Works, *read* Dictionaries.
——————— p. 7, line 16, *for* a plan, *read* a scheme.
——————— p. 8, line 12, *for* of plan, *read* of method.
——————— p. 9, line 2 from bottom, *dele* word, plan ; and in line 9 from bottom, *dele* words, several *and* separate.
——————— p. 10, line 16, *for* plan, *read* arrangement.
——————— p. 11, line 2 from bottom, *for* its plan, *read* its range.
——————— p. 13, line 11, *dele* the words, of literary enterprise.
——————— —— line 15, *for* task, *read* charge.

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ADDENDA, in some copies, p. 833, after line 4, *dele* the words, during the last half century.

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* As it may be of use, both to the Readers and Authors of these Articles, to be able to ascertain the period of the publication of each of the Parts or Half Volumes in which this work was issued, it has been accordingly judged proper to record the following Memorandum in this place: Vol. I. Part I. December 1815; Part II. June 1816.—Vol. II. Part I. December 1816; Part II. June 1817.—Vol. III. Part I. February 1818; Part II. January 1819.—Vol. IV. Part I. December 1819; Part II. September 1820.—Vol. V. Part I. July 1821; Part II. May 1822.—Vol. VI Part I. April 1823; Part II. April 1824.

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*** Place the Preface and Signatures, the General Advertisement, and First Part of the First Dissertation, in the order in which they are here named, at the commencement of the first volume; the First Part of the Second Dissertation at the commencement of the second volume; the Advertisement to the third volume, and the Third Dissertation, at the commencement of that volume; the Advertisement to the fourth volume, and the Second Part of the Second Dissertation, at the commencement of that volume; and the Second Part of the First Dissertation, with its Advertisement, at the commencement of the fifth volume. Place the General Table of Articles and Treatises at the end of the sixth volume, after the Addenda. Cancel the separate Tables of Signatures and Articles for the different volumes.